Winter 1988

Rowcover modification of carbon and mineral nutrient partitioning in strawberry (Fragaria ananassa, Duch)

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Order Number 8907440

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Gast, Karen Lynn Brownlee, Ph.D.

University of New Hampshire, 1988

ROWCOVER MODIFICATION OF CARBON AND MINERAL NUTRIENT PARTITIONING IN STRAWBERRY(*Fragaria ananassa*,Duch.).

BY

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DISSERTATION

Submitted to the University of New Hampshire
in Partial Fulfillment of
the Requirements for the Degree of

Doctor of Philosophy

in

Plant Science

December, 1988

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DEDICATION

I dedicate this work to my mother. My mother and father had the foresight to assure their daughters the opportunity to better themselves through higher education. Since my mother can now only live through her children's accomplishments, I hope my life and work will always reflect favorably on the morals and principles she instilled in me.

ACKNOWLEDGMENTS

First and foremost, the most wonderful man in the whole world, Alan Gast, the man I married. How many men do you know who would give up a wonderful job in a wonderful place, Boulder, CO, to follow his wife 2100 miles to pursue an endeavor such as this, and then spend three and a half hours every week day commuting to Boston to support her? There are very few like him, and I am very blessed to be given such a person to share my life with. Thank you for your patience, your assistance and being there for me, Alan.

Jim Pollard, thank you for taking a chance on me as your graduate student; for giving me the "space" I needed to grow academically and professionally; for trying to proof my two manuscripts and dissertation in a two week period so I could have every thing done before we went to Italy; and for all the advise you have given me. I hope my work will always reflect well upon you.

Owen Rogers, thank you for being such an approachable person. It was very comforting to know that administrators do not have to be intimidating people.

Thelma Stolzenberg, thank you for all the encouragement and advice you gave along the way.

John McLean and the farm crew, thank you for making the field work enjoyable, for all the help you provided and for the bad jokes.

Bob Parker and Bill Given, thank you for all your help in the greenhouse and for our intellectual discussions about topics other than plant science.

My committee members, thank you for all the help you have given me along the way and for taking the time to read this.

And finally my parent, thank you for teaching me to believe in myself and for never discouraging me when I reached for the stars.

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ABSTRACT

ROWCOVER MODIFICATION OF CARBON AND MINERAL NUTRIENT PARTITIONING IN STRAWBERRY(*Fragaria ananassa*, Duch.).

by

Karen Lynn Brownlee Gast
University of New Hampshire, December, 1988

In cool temperature climates where plant growth may be limited by short growing seasons and low temperature stress rowcovers are being used to increase production of fruit and vegetable crops. Two field experiments were conducted to investigate how floating rowcovers applied during autumn, winter and spring affect plant growth and development. The first experiment, 1985-86, examined mineral nutrient and biomass partitioning in a short-day cultivar, 'Sparkle', and a day-neutral cultivar, 'Fern', in rowcovered and nonrow-covered plants in autumn. The second experiment, 1986-87 examined carbon, nitrogen and biomass partitioning over time in autumn and in spring and development of yield components for the short-day cultivar 'Earliglow' in response to an autumn rowcover plus a short-term winter mulch and to no rowcover in autumn plus a long-term winter mulch.

In 1985-86 a rowcover in autumn extended the fall growing season by approximately three weeks increasing degree days(base 5^{o}C) by 63.5. For 'Sparkle', percents nonstructural carbohydrate and nitrogen in plants were lower and biomass in the canopy was higher under rowcovers than for controls. Differences in mineral nutrients were minor. For 'Fern' the only difference between treatments was a slightly higher photosynthetic rate for rowcovered plants.

Time course studies in 1986-87 indicated that rowcovers in autumn sustained the plant canopy, increased soluble sugar content in leaves and delayed development of leaf morphology typical of plants in rest, but had no effect on partitioning of carbon, nitrogen and biomass in other plant organs. In spring plants in the rowcover plus short-term mulch treatment began growth earlier, had higher levels of metabolizable carbon and a lower percent nitrogen than leaves on control plants. The major effect of the rowcovers plus short-term mulch treatment compared to the no rowcover plus long-term mulch treatment was to increase branch crown mass and earliness of flower emergence. It is concluded that use of rowcovers in autumn and winter plus early removal of winter mulch can significantly enhance development of yield components by sustaining plant growth during autumn and spring.

INTRODUCTION

Commercially important strawberry cultivars in the northern United States and southern Canada are short-day types that initiate floral buds in autumn, bloom in late spring, and fruit in early summer. For these cultivars low temperatures can limit floral initiation and delay fruit maturity. Higher temperatures during autumn and spring might increase yield by extending the period of floral initiation and subsequently increase the number and/or size of marketable fruit. In addition, increased spring temperatures and proper choice of cultivar might hasten earliness to fruit maturity and increase yield.

Similar seasonal limitations to vegetable production have been studied at the University of New Hampshire(75,127, 128). Production of peppers, melons, squash, and some cool season vegetables has been increased by application of row-covers which modify the microclimate in the field primarily by elevating temperatures. The technique was applied to strawberries in 1977 using rowcovers of clear slitted poly-ethylene film which had been used successfully to promote earliness in vegetable production(98). These rowcovers were poorly suited for strawberry culture. They required wire hoops for support, foliage in contact with the cover was damaged by freezing temperatures or by sunscald, and fruit production was decreased by a higher incidence of fungal fruit rots. Rowcover research on strawberries in New Hampshire was curtailed until the advent of spunbonded and extruded mesh rowcovers. These lightweight porous materials require no support. They are better ventilated than slitted polyethylene exposing plants to lower peaks of temperature and humidity, yet produce more uniform diurnal temperatures than for non-covered plants.

Rowcover application and removal dates for strawberry were chosen with respect to the phenology of floral bud development. Rowcovers were applied in late summer to early autumn to increase degree days during floral initiation. They remained in place to increase degree days during the short days of late winter and early spring and were removed at bloom to facilitate insect pollination.

Pollard(98) had postulated that extending the growing season by increasing degree days during autumn might increase fruit production by increasing floral bud initiation. In addition, winter survival and vegetative growth in the spring might be improved by increasing carbohydrate reserves.

Research from 1983 through 1985 showed that fruit production could be increased by 30-120% and that earliness could be enhanced 10-14 days by timely application of rowcovers(99). Several factors contributed to annual variations in yield including weather conditions, cultural practices and cultivar response. Pollard and Cundari(99)'s work also suggested that rowcover effects on yield were occurring in late winter and early spring rather than exclusively in autumn as originally postulated. By understanding the physiological basis for yield increases with rowcovers recommendations for more effective rowcover design and application techniques might be refined.

The objective of this study was to examine canopy development, partitioning of dry matter, changes in metabolizable and non-metabolizable carbohydrates, and changes in mineral nutrient composition of strawberry plants during acclimation to seasonal change in a rowcover modified environment. The first experiment examined the responses of two cultivars of different flowering habit, a short-day type, 'Sparkle', and a day neutral type, 'Fern', to autumn only application of rowcovers. The second experiment focused on the development of yield components in the short-day cultivar, 'Earliglow', during acclimation under rowcovers.

I. LITERATURE REVIEW

The cultivated strawberry, *Fragaria ananassa*, Duch., is one of the most common and widely grown fruits in temperate and sub-temperate climates. It is a C-3 plant adapted for optimum growth at relatively cool temperatures, but it can survive in a wide range of climates if given adequate water and proper enivironmental cues for reproduction. Climatic adaptability is a trait which is usually controlled multigenically. For species with a high ploidy level, such as 8x in *F. ananassa*, genotype variability for multigenically controlled traits, such as climatic adaptability, increases greatly.

History

Commercially important strawberry cultivars originated as a hybrid of *F. virginiana* and *F. chiloensis*, two New World species. *Fragaria virginiana* was exported to Europe in the 1600's from Virginia through colonial trade, while *F. chiloensis* has a more illustrious journey to the Old World. In August 1714, Amedee Francois Freizer, French spy and somtimes impulsive plant collector, brought *F. chiloensis* plants to France. The large flavorful fruit of the New World species were attractive to European botanists, so Freizer selected plants with the largest, most flavorful fruit. Unknown to him, *F. chiloensis* exhibits a high degree of dioecism leading to his selection of only female plants.

The large size of the plants and fruit compared to the native European species, F. vesca, is attributable to the difference in ploidy level; F. virginiana and F. chiloensis are octoploids(8x) while F. vesca is a diploid(2x). In the early 1700's, plant sexuality, dioecism, chromosome numbers, ploidy levels and genetics were concepts yet to be understood(26).

Lack of male plants and inability of native species to cross pollinate due to differences in ploidy levels, resulted in F. chiloensis being unfruitful. Eventually pollen producing F. virginiana plants were introduced which successfully crossed with F. chiloensis. The progeny of this cross were first described by Antoine Nicolas Duchesne, who named them F. ananassa Duch(26).

Anatomy and Morphology

Strawberries are herbaceous perennials and have the typical rosette morphology of such species. The overwintering form consists of a compressed stem or crown, a root system and a few leaves. Natural reproduction is either sexual from seed which are dispersed by animals or asexual from above ground stolons which produce daughter plants and branch crowns. Sexual reproduction is initiated in short-day type strawberries by temperature and photoperiod cues. Commercially important strawberries in cool temperate climates are primarily short day-types. They require short photoperiods and cool temperatures for floral bud initiation and the induction of rest(23,45,51,102). Long photoperiods and warmer temperatures promote vegetative growth.

Strawberries have a fibrous root system, which serves as the major storage organ for carbohydrates during rest(79). During the growing season, root dry weights remain constant until late summer and early autumn(71). At this time carbohydrates begin to accumulate in storage tissues in response to decreasing temperatures and shortening photoperiod(102). Dry weight of storage organs increases to a maximum at the onset of rest and remains high through winter until spring growth and fruiting deplete the stored reserves(71).

Strawberry crowns are stems with compressed internodes. They contain the apical meristem, leaf primordia and axillary buds. Crown diameter has been positively correlated with leaf and leaf primordia number(62). Axillary buds can differentiate to become inflorescences, stolons, or branch crowns, depending on the temperature and photoperiod stimulus received. Stolon formation is favored when photoperiods are long and temperatures above 20^{o}C. Branch crown formation occurs under shorter photoperiods when stolon formation has ceased and before rest begins(44,112). Floral buds are initiated under short photoperiods and low temperature usually in autumn, but occasionally in spring if climatic conditions are favorable.

Strawberry leaves are trifoliate with a pair of stipules. Leaf and stipule size is dependent on cultivar. Leaf size and configuration are dependent on season of emergence rather than on time of initiation(4). Short photoperiods and low temperatures decrease leaf area and petiole length (4,7,60,63,86). Decreases in both cell number and size account for the size reduction(4). Arney(7) found that cell expansion decreased at temperatures below 45°F(7.2°C) and cell division ceased at short photoperiods. It has been shown that during short photoperiods, as in autumn, photosynthates accumulate in leaves, increasing specific leaf weights(36). Long photoperiods prolong cell division and elongation leading to elongated petioles and expanded leaf areas(7,52).

Leaf emergence and initiation are affected by different stimuli. Temperature is usually the limiting factor for leaf emergence(3,5), partly explaining why leaf initiation outpaces emergence during rest. Inhibition of leaf emergence during photoperiodic induction of inflorescences also explains why leaf emergence declines during rest(36). With increasing temperatures and lengthening photoperiod in the spring, this inhibition is overcome and temperature becomes the only limiting factor for emergence which now outpaces initiation(6).

Leaf longevity is determined by the time of leaf emergence. Leaves that emerge in spring and summer senesce after several weeks while leaves that emerge in autumn and overwinter survive for several months(26). The plastochron interval at 20°C is eight days and leaf insertion is spirally five in two revolutions(46).

As discussed earlier, floral bud initiation is induced in short day types when plants are exposed to short photoperiods and low temperatures. At higher latitudes the proper conditions usually occur only in autumn, though initiation of inflorescences under short photoperiods in spring has been recorded in climates where temperatures are high enough to facilitate growth and metabolism.

The strawberry inflorescence or truss results from the differentiation of a leaf axil bud into a reproductive bud. The extent of truss development is thought to be dependent upon plant vigor, length of growing season, and crown size and position on the plant(44). Two leaves are the minimum number between trusses while three to four are the norm(46).

The truss is a raceme with dichotomic branching. Flowers and fruit are ranked in order on the truss. There is usually one primary flower, followed by two secondaries, four tertiaries and eight quarternaries, but there can be various combinations. Only fruit from primary, secondary and sometimes tertiary flowers are of commercial importance because the others are too small and develop too late to be of value.

The flowers have ten sepals and five white petals. There are 20-35 stamens in two rows surrounding an enlarged receptacle with 60-600 attached pistils. Self pollination occurs but insect pollination produces larger berries. The strawberry fruit is botanically an achene. Several hundred achenes are attached to an enlarged receptacle, which is commonly known as the "berry" and is considered the fruit for horticultural purposes(85).

Stolons are elongated stems. Specifically the first two internodes of a branch crown are elongated and terminate in a crown of "daughter plant" which may have stolons of its own. Stolon growth is more vigorous during the higher temperatures and long photoperiods of summer.

Physiology

Photosynthesis

Documentation of the effects of changes in sink demand, light intensity, photoperiod and temperature on photosynthesis in strawberry and related species is limited. Present literature suggests that the strawberry adjusts photosynthetically to changes in temperature in ways similar to other species(23,30,65,111,116,117,119).

While investigating the effects of fruiting on photosynthetic rates, Choma et al.(17) found that leaves of fruiting plants had a higher rate of photosynthesis than leaves of nonfruiting plants. Because fruiting plants had fewer leaves, there were no differences in net photosynthesis per plant. The data showed that plants without a strong reproductive sink partition photosynthates to canopy growth and development and that the photosynthetic apparatus can increase its output when sink demand for photosynthates increases.

Three studies were found which examined the effect of light intensity on photosynthesis in strawberry. Sruamsiri and Lenz(116) determined optimum light intensities for photosynthesis. They found the light saturation point to be 50 kLx. Investigating photosynthetic gas exchange of F. vesca, Chabot and Chabot(13) found a poor correlation between changes in leaf anatomy and gas exchange ratios relative to light intensity and temperature. Studying the ontogeny of photosynthetic performance in F. virginiana under changing light regimes, Jurik, et al.(65) found that expanding leaves could change their photosynthetic rate in response to altered light conditions but this ability decreased as leaf expansion was completed.

Photoperiod which is an important regulator of other plant physiologoical processes was found to have no effect on photosynthetic rates in short-day and day-neutral types of strawberry at a constant temperature of $21^{o}C$(31).

Sruamsiri and Lenz(117) found $15^{o}C$ to be the optimum temperature for strawberry photosynthesis, although many researchers believe the optimum temperature for photosynthesis is correlated with the seasonal temperature. It has been found that the mean maximum temperature of the preceeding ten day period will be the optimum temperature for photosynthesis(45,70). Winter annuals which have a growth habit similar to strawberry were found by Regehr and Bazzaz (104) to shift their photosynthetic temperature optimum depending upon the season. At low temperatures light compensation points for Erigeron canadensis, E. annusis, Lactuca scariola and Capsella bursa-pastoris were lowered from 75 micromoles$\cdot m^{-2}\cdot s^{-1}$ at $25^{o}C$ to 18 micromoles$\cdot m^{-2}\cdot s^{-1}$ at $5^{o}C$. The startup time for photosynthesis after a dark period was shortened to only a few minutes and the maximum rate was reached in twelve minutes.

Net photosynthesis and translocation of photosynthates decreases with decreasing temperatures. Activity of some photosynthetic enzymes like malate dehydrogenase(NADP) and pyruvate pyrophosphatase, are reduced at low temperatures (123). In pea(Pisum sativum) a cold tolerant plant, the K_m of some enzymes(i.e. invertase) decreases when growing temperatures are decreased(19). Ribulose-1,5-bis phosphate carboxylase/oxygenase activity normally decreases in woody species as temperatures decrease causing a lower rate of photosynthesis(124).

Shomer-Ilan and Waisel(110) found qualitative changes in the amino acids in ribulose-1,5-bisphosphate carboxylase/ oxygenase when it was exposed to cold temperatures and that its hydrophillicity was increased. Huner and MacDowall(57) found only conformational changes in this enzyme as a result of acclimation to cold.

Low temperatures not only reduce enzyme activity but also slow photosynthate transport from the chloroplast(54, 89,107). Accumulation of photosynthates in the chloroplast seems to reduce the photosynthetic rate. Nafziger and Koller(89) have proposed two hypotheses to explain why accumulated starch reduces the photosynthetic rate. The first hypothesis is that when chloroplasts are expanded with starch cytoplasmic streaming is curtailed. The other hypothesis is that CO_2 diffusion is impeded within the cell by chloroplasts expanded with starch. The studies of Dornhoff and Shibles(29) on leaf anatomy and morphology in relation to carbon dioxide exchange gave results agreeing with those of Nafzigar and Koller(89) who concluded that structural characteristics within the cell have a greater effect on photosynthetic rate than resistances related to stomata, intercellular spaces or cell surfaces.

Carbon Metabolism

Unlike some members of the family Roseacae, strawberries utilize sucrose as the transport carbohydrate(36), while accumulating glucose and fructose in fruit(37).

Carbohydrates can be generally classified as structural and nonstructural. Once a carbohydrate is committed to a structural form such as cellulose or hemicellulose, the plant can no longer utilize it in metabolism. Most plants do not produce the hydrolytic enzymes required to catabolize these structural forms. Nonstructural carbohydrates are utilized in metabolism as fuel for respiration, as skeletons for biosynthesis of compounds including structural carbohydrates, amino acids, secondary plant products, etc., and as starch storage reserves during periods of dormancy or rest. Structural carbohydrates constitute the bulk of plant biomass. Increases in plant dry weight and organ numbers are indicative of partitioning photosynthates to structural forms for growth instead of to nonstructural forms.

A shift in partitioning of photosynthates from structural to nonstructural forms occurs in response to lower temperatures and short photoperiods(71,77). In autumn, as canopy growth slows, nonstructural carbohydrates accumulate in leaves(15,30,71,77), resulting in increased specific leaf weight(36). The effects of lower temperatures and shorter photoperiods in autumn on soluble sugar levels is not clear. O'Neil(94) and Long(72) found that strawberry acclimation to lower temperatures and shorter photoperiod is accompanied by an increase in soluble carbohydrates in leaves, while Maas(77) found the opposite. In other species, starch accumulates during short days and is then degraded to sugars which are translocated to crowns and roots at night(61,71,77,79).

Nutrition

An adequate supply of mineral nutrients is required for the completion of the life cycle of all plants. If environmental conditions are conducive to active growth there will be a demand for nutrients, as constituents of proteins, cofactors, enzymes and electrolytes.

In strawberry adequate nitrogen levels are required for plant growth(18) and especially affect individual berry weight(18), floral initiation(73) and leaf area (73,106). Phosphorus, in addition to nitrogen, is also required for branch crown development(1). Long photoperiods were found to accentuate nutrient deficiencies(67). This effect is probably a coincidental since the most active vegetative growth in strawberry occurs in mid summer under long photoperiods when demand for nutrients is high.

Nutrient uptake in strawberry is highly variable. Peterson et al.(96) and Souza et al.(114) found that cultivars differ in ability to accumulate nutrients. Uptake rates can depend on whether the plant is in a reproductive or vegetative phase. Ganmore-Neumann and Kafkafi(38,39) found nitrate was the prefered nitrogen form at flowering while ammonium was preferred during vegetative growth. Yield component response to added nitrogen can be variable. Some have found that nitrogen applied the summer before harvest increased flower and fruit numbers(73) while others found decreases in these yield components and in plant growth when plants were fertilized under similar conditions(42).

In strawberry, mineral nutrient levels in plant organs fluctuate seasonally. There is debate over the pattern of fluctuation and which nutrients fluctuate. Greve(43) found that nitrogen levels decreased under short photoperiods, while Long(71) found increases under short photoperiods until November, then decreases. John, et al (64) and Cutcliffe and Blatt(22) found that nitrogen and other essential elements, except iron and manganese reached maximum tissue concentrations at bloom and then declined until autumn at which time they began to increase again.

Carbon/Nitrogen Ratios

Kraus and Kraybill(66) were the first to examine the relationship of carbohydrate and nitrogen levels in terms of plant growth and development. Their work with tomato has been interpreted by some as supporting the theory that increases in the carbon to nitrogen ratio are important for induction of floral initiation(9,21,55). The theory states that the shift from vegetative growth to reproductive growth and vice versa is a result of changes in the nutritional status of the plant, especially the relationship of carbohydrates to nitrogen. Higher carbon/nitrogen ratios are thought by some to induce reproductive growth. Their work gave evidence that a change in this ratio is a factor in development of previously initiated reproductive structures, but did not support the claim that induction of flower initiation was dependent on carbon/nitrogen ratios (10).

Greve(42,43) conducted experiments to investigate the nutritional status theory of floral initiation in strawberry. In his first experiment, Greve attempted to change carbon/nitrogen ratios by applying nitrogen fertilizer three times during the growing season, 5 June, 12 July and 20 August at 150 lb/A(42). The ratio was found to decrease in plants receiving fertilizer. These plants also had fewer stolons, leaves and flowers. These changes in plant development were attributed to the decrease in carbon/nitrogen ratio.

In a subsequent experiment, the effects of an eleven hour photoperiod on floral bud differentiation, plant dry weight, total nitrogen, total carbohydrates and carbohydrate/nitrogen ratios were examined(43). Floral bud differentiation correlated with the short photperiod. Also associated with the short photperiod was an increase in total carbohydrates, dry weights and carbon/nitrogen ratio; and a decrease in total nitrogen. From this evidence, Greve(43) concluded that floral bud differentiation is dependent on the nutritional status(carbon/nitrogen ratio) of the plant.

Development

Temperature

Plant growth and development is determined by many environmental stimuli including light intensity, photoperiod, moisture, nutrition and especially temperature. To quantify the effect of temperature on plant physiological processes, the concepts of heat accumulation units or growing degree days and chilling requirement units were developed(28). Mean diurnal or hourly temperatures are subtracted from a standard base temperature and then summed over a specified time to calculate the cumulative hours above or below the base temperature a plant has experienced. The determination of the base temperature for growing degree days is based on observation of the minimum temperature required for growth or a specific physiological process. This information can be used to determine heat unit requirements for harvest, bloom, insect pest emergence and disease infection. If temperature is modified in a plant's environment through experimentation, growing degree-days or chilling requirement, units can be used to quantify the temperature differences the plant experiences. This information can then be used to explain and quantify differences in plant development.

Minimum temperatures are also important in determining when a developmental process will begin or end. The minimum temperature for leaf emergence of strawberry was determined to be 41°F(5°C)(3). Went(129) found 6°C to be sufficient for flower opening. Using this finding and the concept of growing degree-days, Zych(130) used an arbitary base of 45°F (7.2°C) to calculate days to anthesis and to harvest for several strawberry cultivars.

Photoperiod

Commercially important strawberries respond to short photoperiods for floral initiation. There are other types called day-neutrals, which do not respond to photoperiod. There are also the so called "everbearers" which initiate floral buds in response to long photoperiods and high temperatures. These classifications are deceiving in that temperature and photoperiod interact in all types to regulate floral bud and stolon initiation. For example, with respect to flowering, short day types could be considered day neutrals at moderate temperatures and long photoperiods. This is seen naturally in the Watsonville Area of California where strawberries will fruit continuously through the summer. Day neutrals might be considered everbearers with respect to flowering at high temperatures. Therefore these classifications of flowering types may not be appropriate for strawberry(30).

Rest, Hardening and Acclimation

In temperate climates strawberries have evolved to survive seasonal climatic stresses. Acclimation to winter stresses is termed hardening and rest. Hardening is defined as the development of a resistance to low temperatures in autumn to survive subsequent colder temperatures. Development of hardiness can be facilitated by factors that limit growth such as reduced nitrogen, drought, low temperatures and short photoperiods. Besides these factors adequate carbohydrate levels in leaves are required for hardiness as shown in studies where light exclusion hindered development of hardiness(11,12,16,40,92,102,103). Although short photoperiods are listed as facilitators of hardening, Gates(40) found that plants exposed to a temperature just above freezing under long photoperiods accumulated sugars as if they were being hardened by exposure to short days.

Examination of leaves of F. virginiana on a cellular level by O'Neil(94) showed that an increase in cellular osmotic potential via increased soluble sugar concentration was correlated with low temperature acclimation. Young leaves acclimated readily while older leaves did not.

Rest in strawberries is induced by low temperatures and short photoperiods(14,23,24,25,45,59,102). Unlike rest periods in woody species, growth in strawberry is not completely arrested at low temperatures. Plants continue to grow but at a much slower rate. During rest, leaf morphology is changed, petiole elongation is arrested and lamina expansion is reduced. Branch crowns are formed instead of stolons, flower buds are initiated, and root and crown dry weights increase(45,46). To overcome rest the plant must accumulate a specific number of hours below a certain temperature to fulfill its chilling requirement. Length or number of hours required is cultivar and climate dependent(25). Rest and chilling have been shown to be required for vigorous vegetative growth during the next growing season(32,45,82).

Yield Components

Anatomical and morphological factors that contribute to fruit development and production have been widely studied and are collectively termed yield components(48,49,50,68,87, 91,93,100,105,115,120,121,122). Morphological characteristics are interrelated and can interact such that compensation can occur if one contributes less than another(47,48, 68). An example would be that one plant may produce many flowers per truss but produce few trusses, while another plant may produce many trusses but have few flowers per truss. Yield components can also be acted upon by environmental factors such as climate, moisture status, plant nutrition and pest incidence.

For strawberries yield component analyses are most frequently performed to evaluate yield potential of new selections from breeding programs and to assess the impact of new cropping systems on yield of existing cultivars (93,120). Different cultivars may have similiar potential for production but for each cultivar that potential may be attained by the development of a different component of yield

(48,49,50,92,120). The primary determinant of marketable yield in strawberry is the number of unblemished fruit that exceed a minimum weight.

Yield is dependent on direct and indirect factors(48, 49,68,100,105,120). Direct factors include the number of marketable fruit per area which is dependent on the density of plants in that given area which is dependent on the cultural system used. The number of fruit per plant results from the complex interrelationship of morphological components that contribute to fruit number and weight. These include number of fertilized achenes per receptacle(92), number of flowers initiated per truss, number of flower buds that will develop into flowers, flower order on the truss (84), number,development and size of the truss(47,105,125), number of trusses per crown(47, 105), and number of crowns per plant(120,122).

Vegetative morphological characteristics not directly involved in the reproductive process have been highly correlated with yield. Among these are crown diameter(62), crown dry weight(120,122), leaves per crown(50,91), leaves per plant(68,120), leaf area(68, 87,115, 120), leaf dry weight(120), and total plant dry weight(48,120). Leaf parameters of the previous autumn are positively correlated with yield(115).

Strawberry fruit production and plant growth are governed by the laws of diminishing returns within a given plant density. Yield potential is subject to inter- and intraplant competition. Researchers have found optimum numbers for leaves(87), crowns(100,121) and plants(49) for maximizing yields.

Rowcovers

Rowcovers are canopies of films or textiles applied in the field to modify environmental conditions and improve growth and production via the greenhouse effect without the expense of a conventional greenhouse. Crops which can not be grown profitably in greenhouses can now benefit from improved growing conditions. In a review of current rowcover research on vegetables, Wells and Loy(127,128) reported the first application of this concept was in the late 1800's and early 1900's. Glass bell-shaped cloches were used extensively as "rowcovers" in Europe at this time. Recently, crop covers have become more extensively used due to the availability of spunbonded, nonwoven fabrics for use in agriculture.

There has been extensive research on effect of rowcovers on yield of vegetables(75,127,128). Temperatures under polyethylene film averaged 4-5^{o}C higher than ambient, female flowers appeared earlier, and depending upon the cultivar, harvests ranged from 3-13 days earlier. Similar results were found with muskmelons and watermelons by others also using ventilated clear plastic film. Increased yields as well as increased earliness have been reported for melons, marrows, cucumbers, peppers and tomatoes by others (33,34,35, 53,118).

Efforts by chemical and plastics manufacturers in the U.S. to increase markets for spunbonded and extruded mesh products, led to promotion of their use by tobacco growers for protecting nursery beds and shading wrapper leaf fields. These materials were subsequently tested and marketed as a viable alternative to clear polyethylene films for use on vegetable crops. Their major advantages over clear plastic films included light weight and high porosity allowing air circulation and moisture penetration, thus circumventing the need for supporting structures for many crop applications.

These materials promote earlier crop maturity, increase degree day accumulation(80,81,118), improve transplant survival(53,126), facilitate earlier planting(80), provide 1-4^{o}F frost protection in spring(80,118), and provide winter protection for fall sown cool season vegetables (128). A longer fall harvest season is possible since these materials offer up to 7^{o}F frost protection in the fall. Exclusion of insect pests and insect disease vectors has also been successfully demonstrated with spunbonded rowcovers(41,76,80,90,126). Increased yields through higher marketable production and product quality are another benefit of these rowcovers (53,80,81,126,127,128).

Recommendations for rowcover use must consider the crop's developmental and physiological requirements, otherwise there may be no advantage to applying rowcovers. Lancaster et al.(69) and Perry and Sanders(95) are among those who found no differences in yield or earliness for cantaloupes and tomatoes when rowcovers were used. Others

(128) have found heat accumulation under rowcovers can interfere with pollination in solanaceous species. Some members of this family will not pollinate if temperatures exceed 30^{o}C, which is not an uncommon occurrence under rowcovers on sunny days.

Another problem with the spunbonded and extruded mesh rowcovers is the exclusion of pollinators. Rowcovers must be removed or bees must be placed under the covers to facilitate adequate pollination and fruit set in entomophilous species. The latter method has been successfully employed with melons using wide rowcovers(76).

Strawberries and Rowcovers

Because of their low herbaceous growth habit, strawberries are well adapted to rowcover culture. The first approach for using rowcovers was to hasten fruit maturity by an early spring application. It was postulated that increased heat accumulation under rowcovers during cool spring days would promote earlier growth, flowering and fruit maturity and possibly provide some frost protection(98). In 1978, Pollard(98) found reduced yields due to a higher incidence of fruit rotting fungal disease under clear slitted polyethylene films.

Using the same technique but with spunbonded rowcovers, Makus(78) found unacceptable numbers of misshapen fruit which resulted in significant yield reduction. This was likely due to inadequate pollination because the rowcovers were not removed at bloom and excluded pollinators. Rowcovers could also have trapped overwintering catfacing insects in plant and mulch litter facilitating a higher incidence of fruit deformation from insect feeding.

In Florida, increased earliness and marketable yields were found when spunbonded rowcovers were used in conjunction with frost protective overhead irrigation(56). Rowcovers were applied only on nights when there was a danger of frost. Pollination was not impeded during the day. This technique may not be feasible on a commercial scale considering the labor required for application and removal of the covers.

In England, Guttridge and Anderson(48) erected clear polyethylene walk-in tunnels, which allowed air movement and pollinator access. Strawberry plants covered in late February were found to have more flowers per truss and increased, berry weight than controls.

Limited success for spring rowcover application to promote earliness prompted another approach for rowcover use on strawberries. This approach considered the physiology of the strawberry fruiting process. Rowcovers were applied in autumn to optimize growing conditions during floral initiation(8,20,83,88,97,99,101,109). Plants remained covered until anthesis in spring. Benefits of a longer growing season in autumn and spring might include improved winter survival, increased number of floral buds, and increased earliness. Any of these effects could translate into higher yields.

Mason(83) was the first to employ this strategy using glass cloches applied in autumn over strawberry plants. Increased floral initiation resulted from the environmental modification incurred by the glass cloches. Scheel(109) reported considerable yield increases by using clear polyethylene film in this manner. Pritts(101) found that if clear plastics were not removed early in spring, yields could drop below those of non-covered controls.

At the University of New Hampshire Agricultural Experiment Station and other sites, research using the same approach was conducted with spunbonded and extruded mesh rowcovers on perennial strawberry cultural systems(8,20, 88,99,101). At the University of New Hampshire, evaluation of three years of results showed an average yield increase of 4.5 $MT \cdot Ha^{-1} \cdot y^{-1}$, advancement of anthesis by one to three weeks and advancement to fruit maturity by approximately ten days, the response depending on the cultivar(99). Using the similar techniques and materials, Poling(97) found yield increased when rowcovers were used as a protective winter mulch on annual strawberry hill culture in North Carolina.

II. MATERIALS AND METHODS

Experiment I 1985-1986

The experimental design was a randomized complete block with 8 blocks. There were 2 treatments, rowcovered and noncovered and 2 cultivars, 'Sparkle' and 'Fern'. Each block contained one sample plot of each treatment by cultivar combination. Sample plots within blocks contained 11 plants, one guard plant on each end and 9 sample plants.

Dormant crowns of 'Sparkle' (Buntings Nurseries, Selbyville,MD) and 'Fern' (Nor-Cal Nursery, Inc, Red Bluff, CA) were received in May 1985 and stored at $1 \pm 1^{\circ}$ C until planting at the Woodman Horticultural Research Farm, New Hampshire Agricultural Experiment Station, Durham, NH. Plants were sorted and grouped by weight. Those in the middle 50% were selected for planting to reduce variability due to difference in crown size. 'Sparkle' is a short-day flowering type of commercial importance in the Northeastern United States. 'Fern' is a day neutral flowering type developed for California conditions. These cultivars were selected because they represent adaptation for flower initiation under extremely different climatic conditions.

Plants were hand set on 27 June 1985 in a ribbon row with 10 centimeters between plants within rows and 1.3 m between rows. The soil was a Charlton sandy loam, pH 6.4. The field was fertilized prior to planting with 900 kg/ha of

15-15-15. Stolons were removed to maintain planting density. Flowers were removed to promote vegetative growth. Pesticides were applied as recommended for commercial strawberry production by the N. H. Cooperative Extension Service(74). Herbicides were supplemented with hand weeding when required. Irrigation was applied when precipitation was less than 2.5 cm/ week. A winter mulch of salt marsh hay was applied over plants on 9 December 1985 at 39 MT/ha and was removed on 16 April 1986. Rowcovers of 17 $g \cdot m^{-2}$ spunbonded polypropylene 1.5 m X 2.0 m (Kimberly-Clark, Corp. Roswell,GA), were applied on 11 September 1985 and removed on 9 December 1985.

Data Collection

A three-plant sample was removed from each replication for tissue analysis on 25 November 1985 for a fall sample and during the week of 24 March 1986 for a spring sample. Soil and debris were gently removed from the plants by shaking and washing. The 3 plants were pooled, and fresh mass of leaves, crowns and roots was recorded. Tissue samples were dried at 100° C for 1 to 1 1/2 hours and then at 70° C for 24 hours. Dry mass was recorded and the individual samples were ground in a Wiley Mill to pass a 20 mesh screen. A Waring Blendor was used occasionally to pre-grind tissue.

Analyses for the following components were performed on all samples: total nonstructural carbohydrates(TNSC), nitrogen, phosphorus, potassium, calcium, magnesium, manganese, copper, iron, boron and zinc. Analytical procedures were identical for experiments I and II and are described later in this section.

Photosynthetic rates for 2 leaves from each plot were measured between 2 December and 5 December 1985 by an open system differential infrared gas analyzer(Beckman Model 864, Beckman Instruments, Inc., Fullerton, CA). Temperatures in the leaf chamber were adjusted to simulate ambient temperatures experienced by the plants in their respective treatments in the field at sampling (0-5^{o} C). The leaf chamber was cooled by a water bath jacket attached to a refrigerated circulating water bath. Light was provided by tungsten-halogen projector lamps. Photosynthetic Photon Flux(PPF) was set at 600-700 umols$\cdot s^{-1} \cdot m^{-2}$. Air flow through the chamber was 1 l min^{-1}. Leaves remained in the lighted chamber for 30 minutes to determine photosynthetic rate, then were shaded with opaque cloth for ten minutes to determine dark respiration rate. Photosynthetic rates were expressed as mg CO_2 consumed per hour on a fresh mass, dry mass or leaf area basis. Leaf chlorophyll contents were also determined for two 9.0 mm leaf disks per replication.

The remaining 3 plants in each replication were evaluated weekly 16-30 April, 1986, to determine rate of leaf emergence and numbers of leaves.

Temperatures in each treatment were logged by a single continuously recording thermograph (Taylor Weather Hawk, Toronto, Canada) from 5 October to 7 December, 1985 and degree days (base 5^{o} C) were calculated.

Experiment II 1986-1987

The experimental design was a randomized complete block with 6 blocks. There were 2 treatments, rowcovered and noncovered control and one cultivar 'Earliglow'. There were 11 sample plots and 16 guard plots per treatment replication. Plots contained 10 plants. There were 2 guard rows of plots between each block.

Dormant crowns of 'Earliglow'(Nourse Farm Inc., South Deerfield, MA) were received in mid-May and stored at 1 ± 1^{o} C at the Woodman Horticultural Research Farm, New Hampshire Agricultural Experiment Station, Durham, NH. 'Earliglow' was selected because it is a short-day cultivar of commercial importance in the Northeastern United States and has produced significantly higher yields under rowcovers(98).

Plants were hand set on 5 June 1986 in a ribbon row system with 10 cm between plants within rows and 0.9 m between rows. The soil was a Charlton sandy loam, pH 6.6. The field was fertilized prior to planting with 900 kg/ha of 15-15-15 and to rowcover application with 450 kg/ha of 15-15-15. The field was fumigated with methyl bromide and chloropictrin 13 May, 1986. Runners were removed to maintain a constant plant density. Flowers were removed to promote vegetative growth. Herbicides, pesticides and irrigation were applied as described earlier in experiment I.

A soil mulch of saltmarsh hay was applied on 18 June 1986, and renewed as needed during the season. On 22 December 1986, saltmarsh hay was applied to both treatments at a rate of 39 MT/ha. This winter mulch was removed from the rowcovered plots on 27 March 1987 after snow cover had melted, and from the non-rowcovered controls on 24 April 1987, when 25% of the plants were showing growth.

Rowcovers of 22 $g \cdot m^{-2}$ Agronet,(Beghin Say, Kayersberg, France) an extruded polyamide polypropylene mesh, were applied 12 September, 1986. Torn material was replaced twice in autumn and once in spring to maintain integrity of the rowcover treatment. They were removed 12 May 1987 to facilitate pollination.

Data Collection

Three plants were removed from a randomly selected plot in each replication for data collection and tissue analysis. An initial sample was taken 6 September 1986 before rowcovers were applied. Samples were taken at 21 day intervals thereafter until the ground froze. The first spring sample was collected from each treatment on 27 March 1987. Sample collection was at 21 day intervals thereafter until 27 May 1987.

Excess soil and debris were carefully removed from the plants by shaking and washing. In autumn, 3 plant samples were pooled and divided into roots, crowns, leaf blades, petioles, and stolons. In the spring sample plants were divided into roots, crowns, leaf blades, petioles, stolons, flowers and nonfunctional leaves. Nonfunctional leaves were defined as intact attached senescent leaves.

In autumn fresh mass of the divided plant parts and the number of crowns and leaves were recorded. Stolon numbers were recorded only for the last 3 sample times. In spring the above measurements were recorded and in addition flower, stolon, truss and nonfunctional leaf numbers were also recorded for each sample. Dry mass determinations and grinding procedures were identical to those described in the first experiment.

Analyses for total nonstructural carbohydrates and nitrogen were performed on all dried samples. Analysis for fructose, glucose, sucrose and maltose content was performed only on leaf blades.

One plot per replication was designated for analysis of leaf chlorophyll content in autumn, 1986. Two 9.0 mm diameter leaf disks were collected weekly for ten weeks from randomly selected plants. Samples were taken from the most recent fully expanded leaves and were stored in the dark at -20° C until analysis was performed.

After harvest, on 14 July 1987, an entire plot of 10 plants was dug to determine crown number and mass. Plants were collected as previously described.

Soil and air temperatures for each treatment were recorded using copper-constantan thermocouples and a Doric Minitrend 205 multichannel recorder(Doric Scientific, Inc., San Diego, CA). Measurements were replicated 6 times. The recording intervals were one hour for the first recording period, 15 September 1986 to 11 November 1986, and three hours for the second period, 11 December 1986 to 12 May 1987. Soil thermocouples were placed 10 cm below the soil surface; air thermocouples were shaded by chrome-painted T-shaped polyvinyl chloride pipe joints and were placed within the plant canopy 4 cm above the soil surface. Fall data were incomplete due to instrument repairs between 11 November and 11 December. Temperature data were used to determine mean day and night temperatures and to calculate degree day(base 5° C) accumulation(28). Day/night measurement periods were adjusted to compensate for changing daylengths.

Analytical Techniques

Total Nonstructural Carbohydrates(TNSC)

Two to five hundred milligrams of dried tissue from each plant part were boiled for 5 minutes in 15 ml water to gelatinize the starches. This mixture was then cooled to room temperature. Ten milliliters of sodium acetate-acetic acid buffer (pH 4.9) was added to the prepared plant mixture along with 10 ml of 0.5% enzyme solution of Mycolase^{tm} (G. B. Fermentation Industries, Inc., Charlotte, NC), and then incubated at 37°C for 24 h. Mycolase^{tm} converts complex carbohydrates to monomeric glucose units. Lead acetate was added after incubation to denature the enzyme. The solution was then filtered and glucose content of the filtrate was determined by the Shaeffer-Somogyi copper-iodometric titration method. Percent TNSC is expressed as percent glucose per milligram dry mass of sample(113).

Nitrogen

Percent nitrogen in the first experiment and for the fall samples in the second experiment were determined by a standard semi-automatic microkjeldahl procedure at the University of New Hampshire Analytical Services Laboratory, Durham, NH. Spring samples from the second experiment were analyzed by the same procedure at the Ohio Agricultural Research and Development Center(OARDC), Wooster, OH.

Other Nutrient Elements

Percent phosphorus, potassium, calcium and magnesium, and parts per million manganese, copper, iron, boron and zinc were determined for samples from experiment 1 by atomic absorption spectrophotometry at the OARDC.

Chlorophyll Content

Chlorophyll(Chl) concentration was determined by the N,N-Dimethylformamide(DMF) extraction method(58). For each sample 2 leaf disks were manually ground separately in 3 ml DMF and centrifugued at 1250 g for 5 minutes. The supernant was decanted and absorbances were measured at 647 nm and 664.5 nm on a Perkin-Elmer Lambda 3B UV/VIS Double Beam Spectrophotometer(Perkin-Elmer Inc., Norwalk, CO). Mean absorbances for two leaf disks at each wavelength were substituted into equation 1 to calculate chlorophyll concentration. Chlororphyll contents on a leaf area basis were calculated using equation 2.

Equation 1.

Chl Concentration($ug \cdot ml^{-1}$)= A_{647} (17.9) + $A_{664.5}$ (8.08)

Equation 2.

Chl Content($ug \cdot cm^{-2}$ leaf area)= Chl($ug \cdot ml^{-1}$)$\cdot$3 ml$\cdot$0.636 cm^{-2}

This procedure is a modification for terrestrial plant leaves of a procedure developed by Inskeep and Bloom(58).

Soluble Sugar Content

Glucose, fructose, sucrose and maltose, were extracted from one gram of dried, ground leaf blade with boiling 80% ethanol for 5 minutes. The mixture was centrifuged at 17,000 g for 6 minutes at 20^{o} C. The pellet was extracted a total of four times by this method. The supernatants from each extraction were pooled, concentrated in a 50^{o} C water bath, transferred to 25 ml volumetric flasks, and brought up to volume with 80% ethanol. A one ml sample was placed in a 3 or 5 ml Reacti-Vial(Pierce Chemical Co., Rockford, IL), and dried overnight in an oven at 70^{o} C.

Each vial was capped with a screw cap septum and its content was derivatized before determination of soluble sugar content by gas-liquid chromatograghy. Derivatization was by silylation using method number 18 in the Pierce Chemical Co. 1986-87 Handbook and General Catalog(Pierce Chemical Co., Rockford, IL). The procedure was modified by increasing STOXoxime incubation temperature and time to 75-80^{o} C and 40 minutes, respectively. The STOXoxime regent contains 25 $mg \cdot ml^{-1}$ hydroxylamine hydrochloride plus 6 $mg \cdot ml^{-1}$ phenyl-beta-D glucopyranoside(internal standard) in pyridine. One ml of this regent was added to each vial. The vial was heated for 40 minutes at 75-80° C in a water bath then cooled to ambient temperature. Hexamethyldisilazane (HMDS), 1 ml, was added and mixed by shaking. Trifluoracetic Acid, 0.1 ml, was then added and the contents were shaken vigorously for 30 seconds and allowed to stand at ambient temperature for 30 minutes. One ul of the derivatized sample was injected into a gas-liquid chromatograph for determination of soluble sugars. Prior to analysis it was determined that replicates of derivations, injections or extractions were not needed for accurate determinations.

Samples were analyzed on a Perkin Elmer Sigma 300 Gas Chromatograph equipped with dual flame ionization detectors (Perkin Elmer, Norwalk, CO) and Shimadzu CR1-B Chromatopac Integrator(Shimadzu Corporation, Columbia, MD). Gas settings were hydrogen-20 psi, Air-30 psi and helium-40 $ml \cdot min^{-1}$. Temperature program was phase 1, 150° C for two minutes; phase 2, 275° C for 0.5 minutes, with a rate increace of 15° per minute; and phase 3, 285° C for six minutes with a rate increase of 10° per minute. Injector and detector temperatures were 285° C and 300° C respectively. A dual differential column system was used to blank out temperature rise effects on the baseline. Columns were 1.83 m X 2.0 mm internal diameter glass packed with 3% OV-17 on 80/100 mesh Chromosorb W(HP). The chromatopac integrated peaks into concentrations of micromoles per microliters. These values were converted to percent of dry mass and grams sugar per plant.

Statistical Analysis

Statistical analysis of the data was performed by SAS statistical analysis package, specifically PROC GLM. The first experiment was analyzed using ANOVA and orthogonal contrasts. The second experiment was analyzed using ANOVA F-test and effect of sampling time was partitioned into linear, quadratic, and cubic effects.

III. RESULTS AND DISCUSSION

Experiment I 1985-1986

Rowcover Effects on Temperature during Autumn

Mean air temperatures in autumn were 8.8°C for the rowcover treatment compared to 7.1°C for non covered controls. Degree day accumulation for the rowcover treatment was 248.2 compared to 137.1 for controls.

Rowcover Effects on the Cultivar 'Sparkle'

Autumn- During autumn, significant effects of the rowcover on plant dry mass, percent total nonstructural carbohydrates(TNSC), carbon/nitrogen(C/N) ratios(Table 1) and mineral nutrients(Tables 2 and 3) appear to be the result of effects on the plant canopy. Plants in the rowcover treatment had higher canopy dry mass than control plants, indicative of increased vegetative growth and photosynthate partitioning to structural carbohydrates in leaves. Sustained canopy growth provides evidence that increased temperatures under rowcovers extended the growing season and sustained plant growth longer. Partitioning of photosynthates to canopy growth agrees with data from Schaffer, et al.(108), showing that when conditions were conducive to growth, plants without reproductive sinks partitioned more dry matter to leaves than roots crowns(108).

The percent of TNSC was higher in leaves from control

Table 1. Dry mass, percent of dry mass in total nonstructural carbohydrates and carbon/nitrogen ratios in root, crown, canopy and plant for 'Sparkle' strawberry, autumn 1985 and spring 1986.

Treatment and Season	Roots	Crowns	Canopy	Plant
DRY MASS(g)				
Fall				
Rowcover	7.00	4.62	22.84	34.45
Control	6.25	4.28	18.46	28.98
	NS	NS	*	*
Spring				
Rowcover	6.89	3.97	7.31	18.17
Control	6.95	4.33	6.82	18.10
	NS	NS	NS	NS
Season	NS	NS	***	***
TOTAL NONSTRUCTURAL CARBOHYDRATES(%)				
Fall				
Rowcover	19.14	15.71	11.58	13.67
Control	21.63	16.10	15.24	16.72
	NS[y]	NS	**	***
Spring				
Rowcover	22.40	13.75	16.04	17.68
Control	17.53	10.79	12.63	14.10
	**	**	**	***
Season	NS	***	NS	NS
CARBON/NITROGEN RATIOS[z]				
Fall				
Rowcover	12.18	7.12	7.65	8.43
Control	12.74	7.19	8.94	9.38
	NS	NS	*	NS
Spring				
Rowcover	11.85	6.29	8.34	8.86
Control	8.46	4.13	6.31	6.46
	***	NS	**	***
Season	***	*	**	**

[z] Grams total nonstructural carbohydrates per grams nitrogen.
[y] Means within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level by orthagonal contrasts via ANOVA.

Table 2. Percent of dry mass for nitrogen, phosphorus, potassium, calcium, and magnesium; and parts per million of dry mass for manganese, iron, copper, zinc, and boron for canopy and plant 'Sparkle' strawberry for autumn 1985 and spring 1986.

Treatment and Season	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Mn (ppm)	Fe (ppm)	Cu (ppm)	Zn (ppm)	B (ppm)
CANOPY										
Fall										
Rowcover	1.52	0.28	1.85	1.01	0.42	238	272	6.27	29.0	37.1
Control	1.72	0.29	1.73	0.90	0.39	205	229	6.07	26.2	39.9
	**[z]	NS	*	*	NS	NS	NS	NS	NS	NS
Spring										
Rowcover	1.92	0.38	2.04	0.78	0.39	176	675	9.66	26.3	30.3
Control	2.01	0.42	2.20	0.72	0.39	188	473	9.87	50.6	32.8
	NS	*	NS	NS	NS	NS	NS	NS	*	NS
Season	***	***	***	***	NS	NS	***	***	NS	***
PLANT										
Fall										
Rowcover	1.62	0.28	1.53	0.85	0.39	182	380	9.03	48.1	30.7
Control	1.80	0.29	1.43	0.77	0.36	152	355	8.80	46.0	32.1
	*	NS	NS	**	**	NS	NS	NS	NS	NS
Spring										
Rowcover	2.00	0.36	1.41	0.73	0.38	135	1063	14.8	64.5	23.0
Control	2.20	0.38	1.48	0.71	0.39	147	1003	16.2	85.4	24.1
	**	*	NS	NS	NS	NS	NS	NS	**	NS
Season	***	***	NS	**	*	NS	***	**	***	***

[z] Means within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level per orthagonal contrasts via ANOVA.

Table 3. Percent of dry mass for nitrogen, phosphorus, potassium, calcium, and magnesium; and parts per million of dry mass for manganese, iron, copper, zinc, and boron for roots and crowns 'Sparkle' strawberry for autumn 1985 and spring 1986.

Treatment and Season	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Mn (ppm)	Fe (ppm)	Cu (ppm)	Zn (ppm)	B (ppm)
ROOTS										
Fall										
Rowcover	1.58	0.26	0.91	0.40	0.34	60.3	772	8.17	50.8	16.7
Control	1.71	0.26	0.93	0.41	0.34	57.5	783	8.15	50.3	17.2
	NS[z]	NS	NS	NS	NS	NS	NS	NS	NS	NS
Spring										
Rowcover	1.89	0.30	1.02	0.53	0.39	107	1660	12.9	58.1	15.7
Control	2.10	0.32	1.05	0.55	0.41	107	1684	13.5	65.6	16.2
	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
Season	***	***	**	***	***	***	***	NS	***	NS
CROWNS										
Fall										
Rowcover	2.21	0.32	0.94	0.71	0.28	85.3	298	24.0	13.7	20.5
Control	2.30	0.31	0.89	0.72	0.28	71.8	251	21.4	12.5	20.0
	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Spring										
Rowcover	2.37	0.42	1.03	0.96	0.36	116	687	26.9	141	22.2
Control	2.64	0.43	1.06	0.94	0.36	139	727	30.8	174	22.7
	*	NS	NS	NS	NS	NS	NS	NS	**	NS
Season	*	***	***	***	***	***	***	**	***	***

[z] Means within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level per orthagonal contrasts via ANOVA.

than from rowcovered plants(Table 1). When plants are exposed to low temperatures and short photoperiods, nonstructural carbohydrates including starch accumulate in leaves (15,30,71,77). This finding along with those for dry mass suggests that control and rowcover plants at the time of sampling in autumn were not at the same stage of physiological development. Earlier accumulation of TNSC in control plants indicates normal acclimation to short photoperiods and cool temperatures. Plants in the rowcover treatment continued growth as seen by the higher dry mass.

As with carbohydrate partitioning, differences in plant percent nitrogen and calcium were due to canopy differences (Tables 2 and 3). Percent nitrogen in the canopy was higher for control plants than for rowcovered plants (Table 2). Results from previous work(71) show that as rest commences leaf nitrogen increases.

Percent calcium in rowcovered plants were higher than in controls(Table 2). Calcium is an important constituent of cell walls and membranes. Decreased calcium would indicate increased cell wall and membrane degradation which normally occurs during leaf senescence.

Differences in these key nutrients support the theory that plants in these two treatments were not at the same stage of physiological development when tissue samples were collected and that rowcovers extended plant growth and development later in the season.

Carbon/nitrogen ratios were higher in the canopy of control plants than in the canopy of rowcovered plants but there were no differences for the whole plant(Table 1). Greve(44) found that strawberry plants grown in short photoperiods(11 hours) had a higher carbon/nitrogen ratio than control plants grown in longer photoperiods. He attempted to link the increase in carbon/nitrogen ratio to increased floral initiation, but the ratios may be more indicative of the transition between active growth and rest and only coincidentally related to flower initiation. If higher carbon/nitrogen ratios are indicative of this transition, then the differences between control and rowcovered canopies support the premise that the plants in both treatments were in different phases of acclimation to seasonal change when sampled in autumn.

There were no treatment differences in chlorophyll concentrations or photosynthetic rates for 'Sparkle'(Table 4 and 5).

Table 4. Mean chlorophyll content($mg \cdot cm^{-2}$) of leaves for 'Sparkle' and 'Fern' strawberry, autumn 1985.

Cultivar	Mean Chlorophyll Content($mg \cdot cm^{-2}$)		
	Rowcover	Control	Significance
SPARKLE	58.12	54.51	NS
FERN	51.33	57.33	NS

[z] Within rows, nonsignficant(NS) or significantly different from the control at the 5%(*) or 1%(**) level per orthogonal contrasts via ANOVA.

Table 5. Mean photosynthetic rates based on dry mass, fresh mass, leaf area and specific leaf weight at ambient temperature(0-5°C)for 'Sparkle' and 'Fern' strawberry, autumn 1985.

	Photosynthetic Rates($mg \cdot CO_2 \cdot h^{-1}$)			
Treatment and Cultivar	Dry Mass (g)	Fresh Mass (g)	Leaf Area (dm^2)	Specific Leaf Weight ($g \cdot dm^{-2}$)
SPARKLE				
Rowcover	4.71	1.59	5.02	5.05
Control	4.25	1.43	4.81	4.32
	NS[z]	NS	NS	NS
FERN				
Rowcover	6.33	2.07	6.03	5.01
Control	4.54	1.56	4.44	3.72
	NS	NS	**	**

[z] Within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level by orthogonal contrasts via ANOVA.

Spring- In spring there were no differences in dry mass between treatments for any plant part(Table 1). The absence of any differences in dry mass may be due to sampling technique. Because senescent leaves were discarded before samples were weighed, only live tissue was included. Although the rowcovered plants had greater canopy mass the previous autumn, many of these leaves probably did not survive as both treatments were treated identically during winter. They were then probably included with the discarded senescent leaves.

Percent TNSC was higher in spring for rowcovered plants than for controls(table 1). This was attributable to higher levels of TNSC in all plant parts. There was a period, approximately two weeks, between the end of autumn sampling and winter mulch application during which rowcovered plants could have continued accumulating more nonstructural carbohydrates. The difference in TNSC between treatments provides more evidence that plants in the two treatments were in different phases of acclimation at the autumn sample date.

Treatment differences for plants were seen for nitrogen in spring(Tables 2 and 3). Plant nitrogen was higher due to higher nitrogen in roots and crowns of control plants. This difference probably resulted from re-translocation of nitrogen from the canopy of control plants to roots during the previous autumn. Re-translocation of nitrogen from leaves to roots is a normal process during acclimation to autumn seasonal change.

The carbon/nitrogen ratio for all plant organs was higher in the rowcover treatment than in the control(Table 1). The higher ratio for rowcovered plants was a reflection of a higher percent TNSC for these plants compared to higher nitrogen in control plants.

Greater storage reserves of TNSC in roots of rowcover plants did not affect rate of leaf emergence and/or leaf number(Table 6). No effect was expected, since temperature is the limiting factor for leaf emergence, and not the amount of stored carbohydrate(2,3,45).

<u>Seasonal Comparisons</u>- There were no autumn to spring differences due to treatment only. There were seasonal decreases in plant dry mass, carbon/nitrogen ratios, parts

Table 6. Mean leaf number per plant over a three week period with weekly leaf counts for 'Sparkle' and 'Fern' strawberry, spring 1986.

Treatment and Cultivar	Leaf Number Week 1	Week 2	Week 3	Statistical Analysis over Time	
SPARKLE					
Rowcover	8.79	12.50	17.75	Treatment	NS
Control	9.42	13.08	17.96	Linear	***
	NS[z]	NS	NS	Lack of Fit	NS
				Treatment x Time	NS
FERN					
Rowcover	6.63	8.63	10.38	Treatment	NS
Control	7.02	9.52	11.94	Linear	***
	NS	NS	NS	Lack of Fit	NS
				Treatment x Time	NS

[z] Within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level by orthogonal contrasts via ANOVA.

per million manganese and boron and percent calcium from autumn to spring(Tables 1, 2 and 3). There were also seasonal increases in parts per million copper, iron and zinc, and percent phosphorus and nitrogen from autumn to spring (Tables 2 and 3).

Seasonal fluctuations of nutrient levels of strawberry petioles were studied John, et al.(64). Most seasonal changes in plant nutrient levels for this experiment agree with theirs in that differences were due to the plant's canopy(Table 2 and 3). Although plant potassium content was not different for either treatment between seasons, the increase of percent potassium in the canopy from autumn to spring also agrees(Table 2.). While seasonal increases in parts per million zinc from autumn to spring were due instead to differences in the crown rather than in the canopy. Seasonal increase from autumn to spring for parts per million iron did not agree.

Percent TNSC in the canopy of control plants decreased from autumn to spring, while percent TNSC in rowcovered plants increased(Table 1). These differences created a significant season by treatment interaction. The interaction is also evidence that plants in the two different treatments were being affected differently by their respective environments in autumn.

Conclusions- Rowcovers increased air temperatures thereby promoting leaf canopy growth as seen by higher canopy dry mass with them than without rowcovers. Higher levels of nonstructural carbohydrates, nitrogen concentrations and carbon/nitrogen ratios in control plants than in rowcovered plants indicate that rest was further advanced in these than in rowcovered plants. The season by treatment interaction for TNSC further showed that plants in the two treatments were not at the same physiological stage of acclimation to seasonal change when they were sampled at the end of autumn. All of this evidence leads to a conclusion that active growth was sustained by rowcovers in autumn.

The greater accumulation of TNSC in rowcovered versus uncovered plants during late autumn provides more reserve carbohydrates to support growth and fruit development in spring.

Rowcover Effects on the Cultivar 'Fern'

Autumn- No appreciable effects were seen in autumn when rowcovers were applied over the day neutral cultivar, 'Fern'. There were no treatment differences in dry mass, percent TNSC, carbon/nitrogen ratio and chlororphyll concentrations (Table 4 and 7). However, rowcovered plants had higher percent potassium than control plants(Table 8), and higher photosynthetic rates based on leaf area and specific leaf weight(table 5).

'Fern' is a day neutral cultivar whose flowering is insensitive to changes in photoperiod and temperature. No references were found to suggest how seasonal change affects growth and developmental processes in day-neutral strawberry. The lack of differences between treatments for 'Fern' as compared to the differences seen for the short-day type, 'Sparkle', may reflect the importance of photoperiod and photoperiod/temperature sensitivity for plant response to environmental modification by rowcovers in the autumn.

Higher root potassium concentrations(Table 7) and photosynthetic rates for rowcovered plants(Table 8) could be possibly due to elevated temperatures under the rowcovers which would sustain photosynthesis and electrolyte uptake. This explanation though does not account for the lack of differences in other electrolytes.

Spring- In spring there were no differences in dry mass due to treatments(Table 7). Roots of control plants had higher percent TNSC than rowcovered plants(table 7). There were treatment differences for percent nitrogen and phos-

Table 7. Dry mass, percent of dry mass in total nonstructural carbohydrates and carbon/nitrogen ratios in root, crown, canopy and plant for 'Fern' strawberry, autumn 1985 and spring 1986.

Treatment and Season	Roots	Crowns	Canopy	Plant
DRY MASS(g)				
Fall				
Rowcover	4.35	3.45	11.21	19.00
Control	3.85	3.59	8.62	16.06
	NS	NS	NS	NS
Spring				
Rowcover	4.60	2.95	2.85	10.40
Control	3.86	2.90	2.01	8.77
	NS	NS	NS	NS
Season	NS	*	***	***
TOTAL NONSTRUCTURAL CARBOHYDRATES(%)				
Fall				
Rowcover	19.29	15.89	16.48	16.99
Control	18.93	15.43	16.13	16.53
	NS[y]	NS	NS	NS
Spring				
Rowcover	14.01	12.09	18.63	14.68
Control	17.04	11.66	17.44	15.43
	*	NS	NS	NS
Season	**	***	*	**
CARBON/NITROGEN RATIOS[z]				
Fall				
Rowcover	12.21	9.87	9.92	10.38
Control	11.18	8.42	9.75	9.73
	NS	NS	NS	NS
Spring				
Rowcover	7.53	7.78	9.35	7.89
Control	8.38	5.65	7.91	7.37
	NS	NS	*	NS
Season	***	**	*	***

[z] Grams total nonstructural carbohydrates per grams nitrogen.

[y] Means within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level by orthagonal contrasts via ANOVA.

Table 8. Percent of dry mass for nitrogen, phosphorus, potassium, calcium, and magnesium; and parts per million of dry mass for manganese, iron, copper, zinc, and boron for canopy and plant 'Fern' strawberry for autumn 1985 and spring 1986.

Treatment and Season	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Mn (ppm)	Fe (ppm)	Cu (ppm)	Zn (ppm)	B (ppm)
CANOPY										
Fall										
Rowcover	1.67	0.30	1.78	0.85	0.36	152	257	5.19	22.2	31.8
Control	1.66	0.32	1.73	0.81	0.35	152	411	5.10	25.8	34.5
	NS[z]	NS	NS	NS	NS	NS	NS	NS	NS	NS
Spring										
Rowcover	2.03	0.38	2.12	0.57	0.33	112	457	7.55	26.0	27.0
Control	2.22	0.42	2.07	0.55	0.33	130	401	8.59	26.1	32.5
	**	*	NS	NS	NS	NS	NS	NS	NS	**
Season	***	***	***	***	*	NS	NS	***	NS	*
PLANT										
Fall										
Rowcover	1.64	0.28	1.46	0.70	0.34	111	406	8.42	39.6	26.2
Control	1.70	0.29	1.35	0.66	0.33	105	505	8.13	44.6	26.9
	NS	NS	*	NS	NS	NS	NS	NS	NS	NS
Spring										
Rowcover	1.90	0.34	1.46	0.65	0.38	116	1288	15.7	68.2	21.2
Control	2.09	0.36	1.41	0.65	0.39	114	1067	21.2	68.7	22.9
	**	NS	NS	NS	NS	NS	*	NS	NS	NS
Season	***	***	NS	NS	***	***	***	***	***	***

[z] Means within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level per orthagonal contrasts via ANOVA.

Table 9. Percent of dry mass for nitrogen, phosphorus, potassium, calcium, and magnesium; and parts per million of dry mass for manganese, iron, copper, zinc, and boron for roots and crowns 'Fern' strawberry for autumn 1985 and spring 1986.

Treatment and Season	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Mn (ppm)	Fe (ppm)	Cu (ppm)	Zn (ppm)	B (ppm)
ROOTS										
Fall										
Rowcover	1.59	0.24	0.96	0.40	0.31	56.1	915	7.90	46.5	16.6
Control	1.70	0.24	0.84	0.40	0.29	58.2	902	7.72	46.8	16.1
	NS[z]	NS	*	NS	NS	NS	NS	NS	NS	NS
Spring										
Rowcover	1.89	0.29	1.14	0.59	0.39	127	2175	15.7	68.1	16.5
Control	2.04	0.30	1.18	0.58	0.40	108	1761	25.2	62.0	17.4
	NS	NS	NS	NS	NS	*	**	NS	NS	NS
Season	***	***	***	***	***	***	***	**	***	NS
CROWNS										
Fall										
Rowcover	1.65	0.276	1.07	0.60	0.32	49.4	245	19.6	87.9	20.3
Control	1.85	0.29	0.98	0.61	0.31	52.4	274	15.6	85.9	20.5
	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Spring										
Rowcover	1.81	0.37	1.34	0.80	0.40	101	718	23.1	109	22.8
Control	2.09	0.39	1.28	0.80	0.40	108	591	24.8	107	23.6
	NS	*	NS	NS	NS	NS	NS	NS	NS	NS
Season	NS	***	***	***	***	***	***	**	*	***

[z] Means within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level per orthagonal contrasts via ANOVA.

phorus, and parts per million boron, manganese and iron (Tables 8 and 9). Higher concentrations of nitrogen, phosphorus and boron in control plants were attributable to higher boron in the canopy, phosphorus in the crowns and nitrogen in both canopy and crowns. Differences in manganese and iron were due to higher concentrations in roots of rowcovered plants.

The carbon/nitrogen ratio was higher in canopies of rowcovered plants than in those of control plants in spring (Table 7) because the latter contained nitrogen(Table 8).

Treatments did not affect spring dates of leaf emergence and leaf number in spring(Table 6). Leaf emergence is primarily limited by temperature rather than reserve carbohydrate(2,3,45).

Seasonal Comparisons- There were no treatment differences between sample dates for parameters measured. For both treatments there were seasonal difference for some growth parameters when the autumn and spring samples were compared. There were decreases in plant dry mass, percent TNSC, carbon/nitrogen ratio, parts per million boron and percent calcium from autumn to spring (Tables 7, 8 and 9). However there were increases in parts per million manganese, iron, copper and zinc, and percent phosphorus, magnesium and nitrogen from autumn to spring(tables 8 and 9).

As discussed earlier John, *et al*.(64) found that iron and manganese decreased from autumn to spring, while nitrogen, phosphorus, potassium, zinc and boron increased. Their results do not agree with ours in respect to fluctuations in total plant potassium, manganese, iron and boron concentrations. Closer examination of our data reveals that seasonal fluctuations of canopy potassium and manganese do agree.

Conclusions- Environmental modification in autumn with rowcovers had no effect on biomass production or on nitrogen and carbon partitioning in the day neutral cultivar 'Fern'. However, there was evidence of greater potassium accumulation by roots and photosynthesis in leaves of rowcovered versus uncovered plants. There were treatment differences in nutrients in spring, but these did not present a pattern which would lead to any discernable conclusions.

Experiment II 1986-1987

Rowcover Effects on Temperature during Autumn and Spring

Mean air temperatures in autumn were 12.3°C for the rowcover treatment compared to 11.2°C for the noncovered control. Mean soil temperatures were 12.6°C for the rowcover treatment compared to 11.3°C for the noncovered control. Degree day(base 5°C) accumulation in air for the rowcover treatment was 443.1 compared to 379.6 for controls.

Mean air temperatures in winter and spring were 4.8°C for the rowcover treatment compared to 3.6°C for the noncovered control. Mean soil temperatures were 3.8°C for the rowcover treatment compared to 2.6°C for the noncovered control. Degree day(base 5°C) accumulation in air for the rowcover treatment was 275.1 compared to 225.1 for controls. These differences in temperatures and degree day accumulation were significant at the 0.1% level.

Figures 1 and 2 illustrate the effect of rowcovers on temperature fluctuation in autumn, winter and spring. When ambient temperatures were low, temperatures under rowcovers were significantly higher than those temperatures in control plots. In autumn, minimum diurnal temperatures averaged 7.3°C in rowcovered plots versus 6.3°C in control plots. In winter and spring they were 3.4°C versus 2.6°C. In addition to modifying the environment when temperatures were low, rowcovers accumulated more heat when ambient temperatures

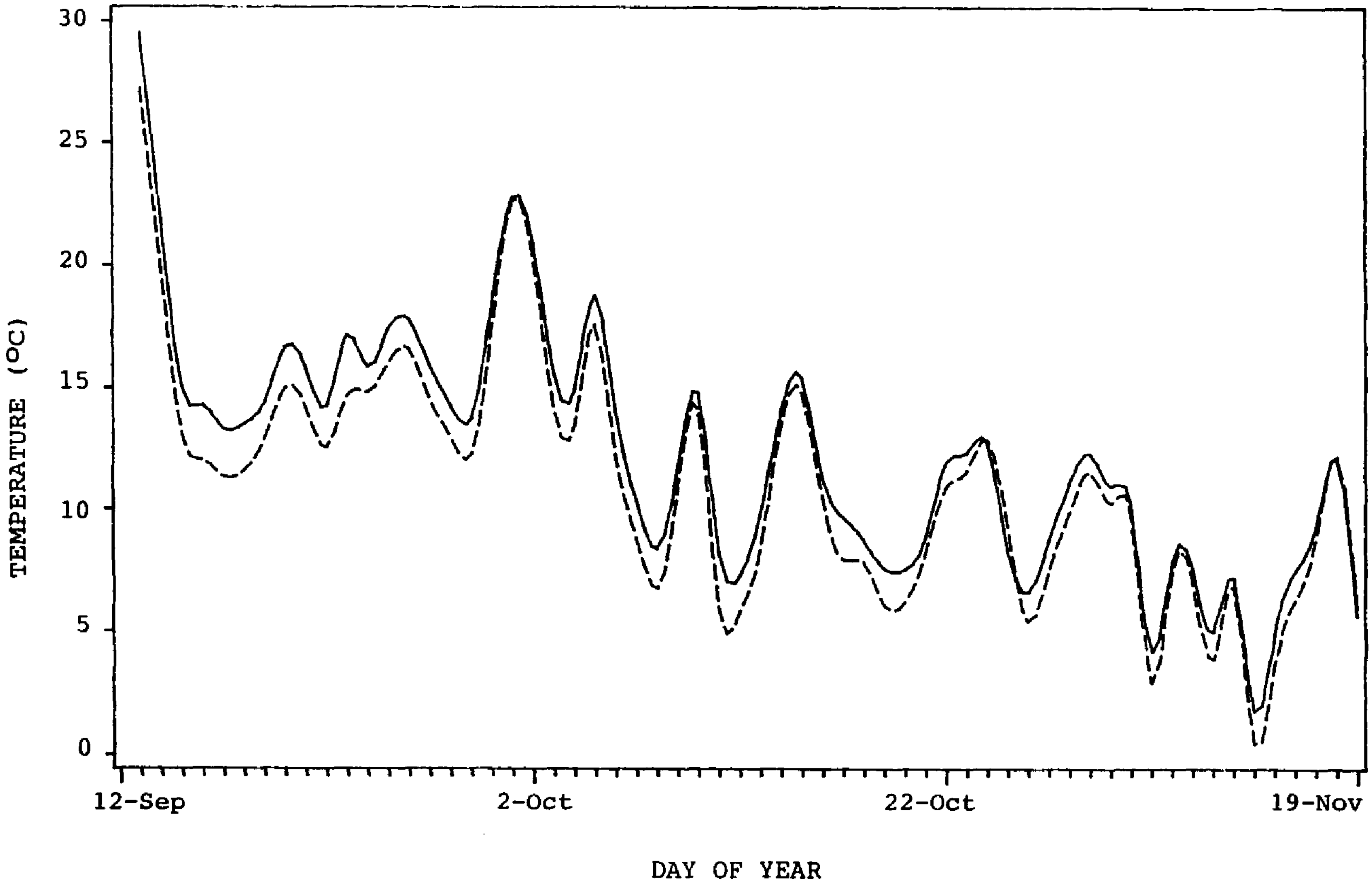

Figure 1. Mean diurnal air temperature(°C) 12 September to 11 November 1986 in 'Earliglow' strawberry plots. Means of six replicates. Rowcover —— and No cover control ----.

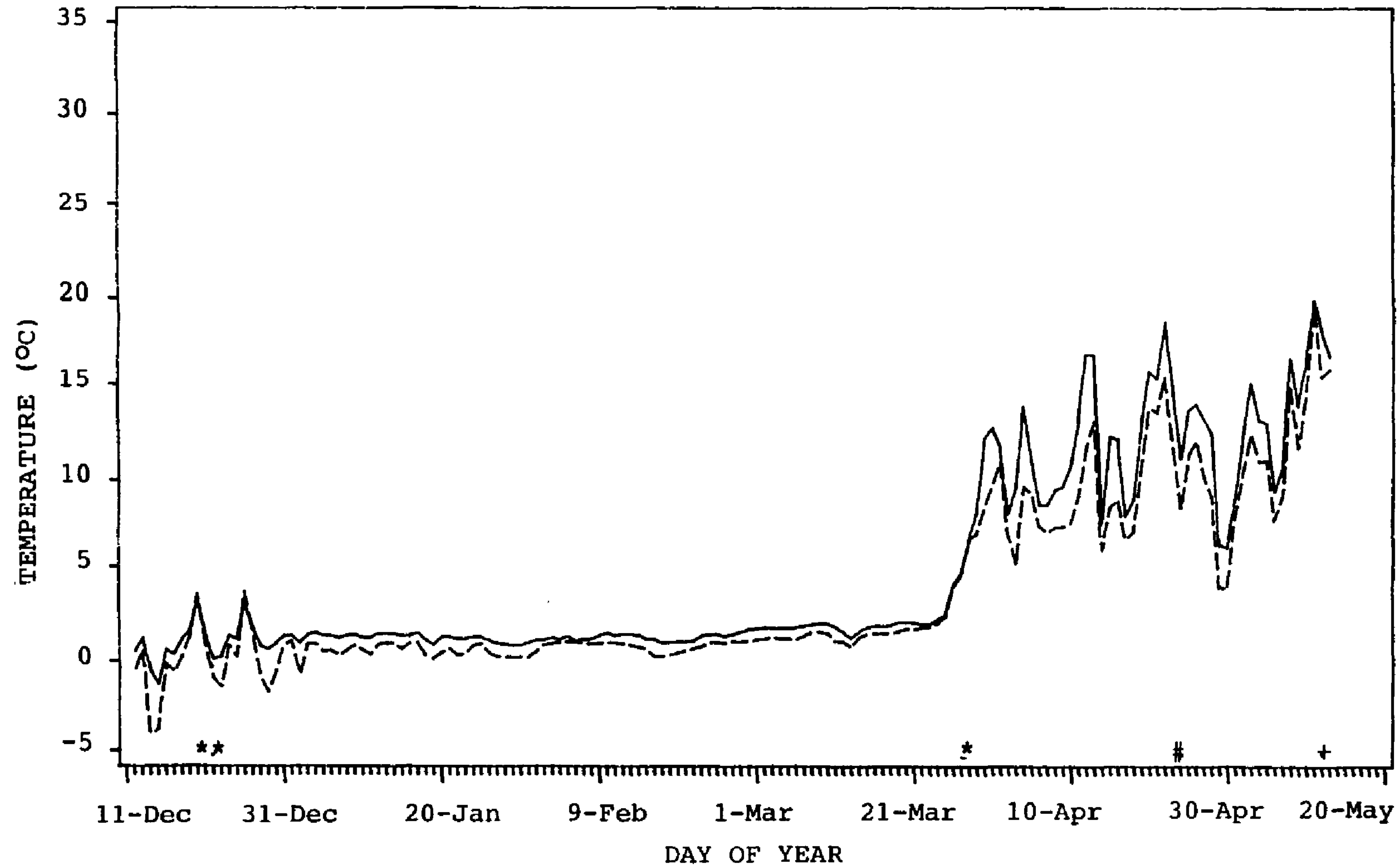

Figure 2. Mean diurnal air temperatures(^{o}C) 11 December 1986 to 12 May 1987 in 'Earliglow' strawberry plots. Means of six replicates. Rowcover ——— and no cover control ------. Rowcover winter mulch removal = *, Control winter mulch removal = #, Winter mulch application = ** and Rowcover removal = +.

were high. In autumn mean maximum diurnal temperatures were $19.0^{o}C$ for the rowcover treatment compared to $16.5^{o}C$ for controls. In winter and spring maximum diurnal temperature in the rowcover treatment averaged 7.4^{o}, while in the control maximum diurnal tempratures averaged $5.8^{o}C$. Snow cover and winter mulches insulate strawberry plants from both low and fluctuating temperatures. The findings of this study show that rowcovers also moderate temperature extremes.

The relatively uniform temperatures in Figure 2. between 1 January and 30 March 1987 were caused by the presence of continuous snow cover. During January 1987, approximately 150 cm of snow accumulated and remained until the end of March.

Rowcover Effects on 'Earliglow' in Autumn

Plant Organ Dry Mass and Numbers - There were no significant treatment differences in dry mass for combine sampling dates for all plant organs with the exception of stolons(Table 10). Stolons in the rowcover treatment had higher dry mass than those in the control. There were treatment differences at individual sample dates. There were no treatment differences at the initial sample date on 6 September 1986(Table 10). By the second sample date on 2 October, crowns in the control had higher dry mass than those in the rowcover treatment. There were no treatment differences again until the last sample date on 3 December when leaves and plants in the rowcover treatment had higher dry mass than the control (Table 10).

Table 10. Dry mass for roots, crowns, leaves, petioles, stolons, and plant for 'Earliglow' strawberry, autumn 1986. Rowcover application 12 September 1986.

Sample Date and Treatment		Dry Mass(g) Roots	Crowns	Leaves	Petioles	Stolons	Plant
6-Sep	Rowcover	1.58	1.95	12.81	4.79	^	21.13
	Control	1.83	1.95	14.64	5.64	^	24.07
		NS[z]	NS	NS	NS	--	NS
1-Oct	Rowcover	3.65	2.92	16.61	7.03	^	30.20
	Control	4.76	3.50	19.61	8.05	^	35.92
		NS	*	NS	NS	--	NS
21-Oct	Rowcover	8.15	3.77	20.51	8.93	1.61	42.96
	Control	7.64	3.79	18.02	7.22	1.20	37.87
		NS	NS	NS	NS	NS	NS
15-Nov	Rowcover	6.29	4.00	15.97	6.74	1.41	34.42
	Control	6.32	4.20	14.99	5.67	0.86	32.13
		NS	NS	NS	NS	NS	NS
3-Dec	Rowcover	6.60	4.05	10.82	4.58	2.06	28.11
	Control	6.82	3.96	8.20	3.90	0.87	23.74
		NS	NS	**	NS	NS	*
Treatment		NS	NS	NS	NS	*	NS
Time							
Linear		***	***	***	*	NS	NS
Quadratic		***	***	***	***	#	***
Cubic		NS	NS	NS	NS	#	NS
Lack of Fit		*	NS	NS	NS	NS	NS
Treatment x Time		NS	NS	NS	NS	NS	NS

[z] Means within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level per F-test via ANOVA.

\# Significance nonestimatable due to missing values in the model.

^ Abscence of tissue or insufficient amounts for tissue analysis.

Total leaf dry mass per plant and per crown are determined by individual leaf mass and by leaf number per plant or per crown. Total leaf area per plant and per crown are determined by individual leaf areas and by leaf number per plant or per crown. When differences in leaf dry mass and total leaf areas are discussed, differences in the parameters which constitute them must be examined to better understand treatment effects.

There were no treatment differences for specific leaf weights at the first, second and fifth sample dates(Table 11). At the third sample date 21 October control leaves had higher specific leaf weights compared to rowcovered leaves, while at the fourth sample date specific leaf weights from the rowcover treatment were higher than for the control (Table 11). It can be seen that there was a delay of approximately three weeks in attaining maximum specific leaf weight in plants under the rowcover treatment(Figure 3). In autumn, as plants enter rest, TNSC increase in leaves which increases the specific leaf weight(15,30,71,77). Higher specific leaf weights seen in Table 11 reflect the increase of TNSC in the canopy(Table 14). Figure 4 shows that the accumulation of nonstructural carbohydrates in leaves under rowcovers follows a pattern similar to that of specific leaf weights. Again there was a delay in attaining maximum levels in plants in the rowcover treatment, even though treatment differences by sample date in percent TNSC of leaves were not statistically different.

On the final sample date in autumn, plants under row-

Table 11. Leaves per plant, leaves per crown, total leaf area per plant, individual leaf area and specific leaf weight for 'Earliglow' strawberry, autumn 1986. Rowcover application 12 September 1986.

Treatment	Sample Date: Sep 6	Oct 1	Oct 21	Nov 15	Dec 3	Statistical Analysis over Time	
LEAVES PER PLANT(no.)							
Rowcover	15.28	17.20	19.61	14.50	13.11	Treatment	NS
						Linear	**
Control	16.00	19.56	17.11	15.28	10.56	Quadratic	***
						Cubic	NS
	NS[z]	NS	NS	NS	NS	Lack of Fit	NS
						TreatmentxTime	NS
LEAVES PER CROWN(no.)							
Rowcover	9.29	9.16	8.82	6.90	5.37	Treatment	**
						Linear	***
Control	8.83	9.66	9.28	7.49	4.23	Quadratic	***
						Cubic	NS
	NS	NS	NS	NS	*	Lack of Fit	NS
						TreatmentxTime	NS
TOTAL LEAF AREA PER PLANT(cm^2)							
Rowcover	1616.5	2093.7	2085.7	1607.1	1274.4	Treatment	NS
						Linear	***
Control	2064.8	2539.6	1554.9	1671.8	1008.2	Quadratic	***
						Cubic	NS
	NS	NS	*	NS	*	Lack of Fit	*
						TreatmentxTime	*
INDIVIDUAL LEAF AREA(cm^2)							
Rowcover	107.00	121.90	106.50	110.60	98.79	Treatment	NS
						Linear	***
Control	130.90	131.00	90.80	108.50	97.27	Quadratic	NS
						Cubic	NS
	NS	NS	NS	NS	NS	Lack of Fit	***
						TreatmentxTime	*
SPECIFIC LEAF WEIGHT($g \cdot cm^{-2} \cdot 10^{-3}$)							
Rowcover	7.99	8.06	9.96	9.97	8.57	Treatment	NS
						Linear	***
Control	7.13	7.78	11.67	9.00	8.21	Quadratic	***
						Cubic	**
	NS	NS	**	**	NS	Lack of Fit	***
						TreatmentxTime	***

[z] Means within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level per F test via ANOVA.

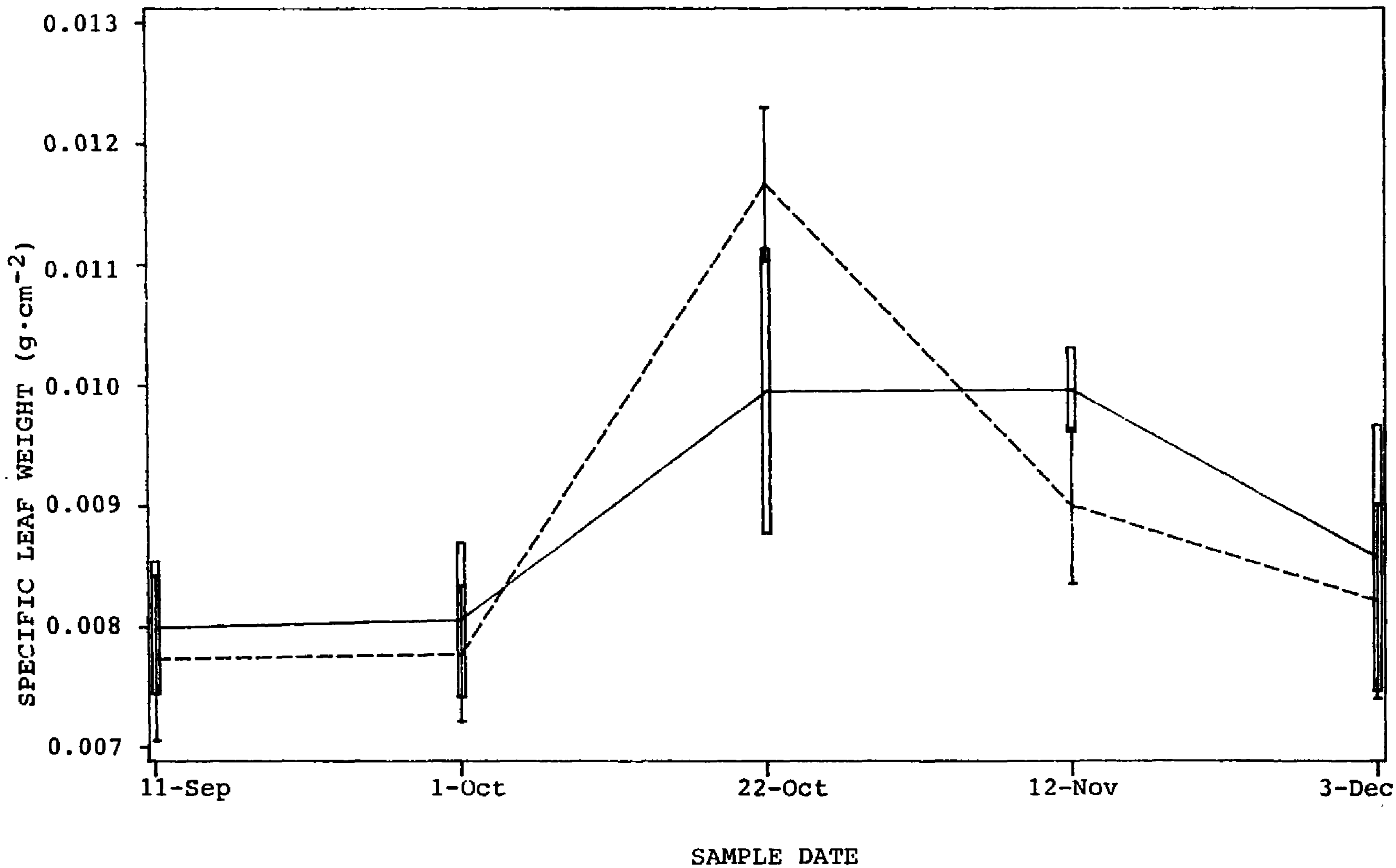

Figure 3. Mean specific leaf weight(g cm^2) for 'Earliglow' strawberry, autumn 1986. Means of six replicates. Rowcover ——— and no cover control -----. Confidence bars STD=1.

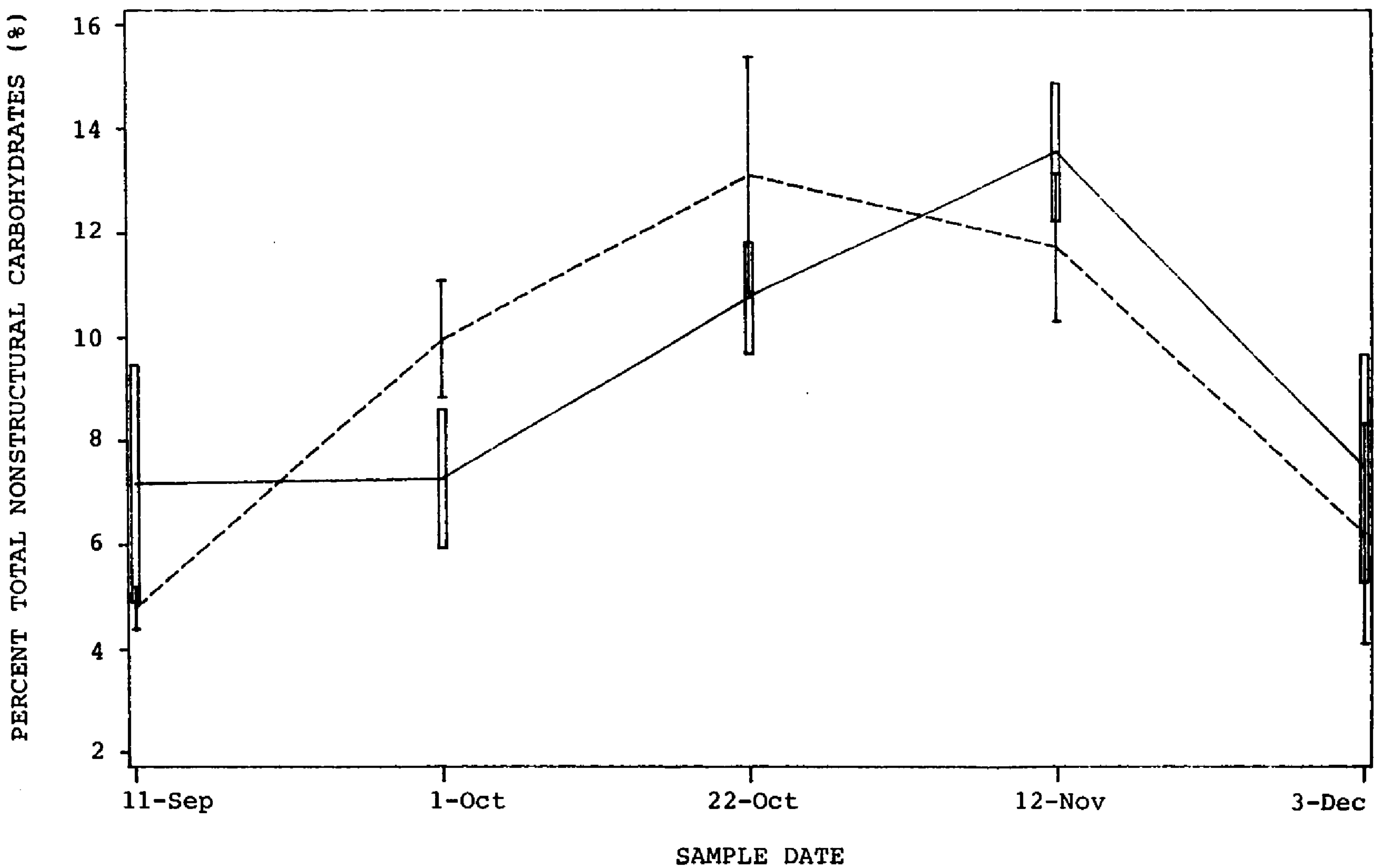

Figure 4. Mean percent total nonstructural carbohydrates of leaves for 'Earliglow' strawberry, autumn 1986. Means of six replicates. Rowcover ——— and no cover control -----. Confidence bars STD=1.

covers had more leaves per crown than control plants(Table 11). Greater leaf numbers per crown were probably the major determinant of higher leaf dry mass in the rowcover treatment since there was no difference in specific leaf weight between treatments at this time(Tables 10 and 11).

An increase in total leaf area for plants under rowcovers was probably the result of there being more leaves per crown, since mean leaf areas were no different(Table 11). Further examination of leaf area data in Table 11 and in Figure 5, shows a significant sample date by treatment interaction for total leaf area. Leaf area on rowcovered plants was sustained longer than on controls. Greater leaf areas, leaf dry mass and leaf numbers supports the conclusion that photosynthetic surfaces were sustained longer in autumn on plants in the rowcover treatment than in the controls.

There were no treatment differences in crowns per plant, nor in individual crown dry mass(Table 12). There were also no differences in stolons per plant nor in individual stolon dry weights suggesting that these organs were not strong sinks for fixed carbon during the treatment period.(Table 13).

Total Nonstructural Carbohydrates and Soluble Sugars - There were differences in TNSC for leaves, roots and stolons on specific sample dates, but there were no treatment differences for the season(Table 14). Differences on specific sample dates were likely artifacts from differences in

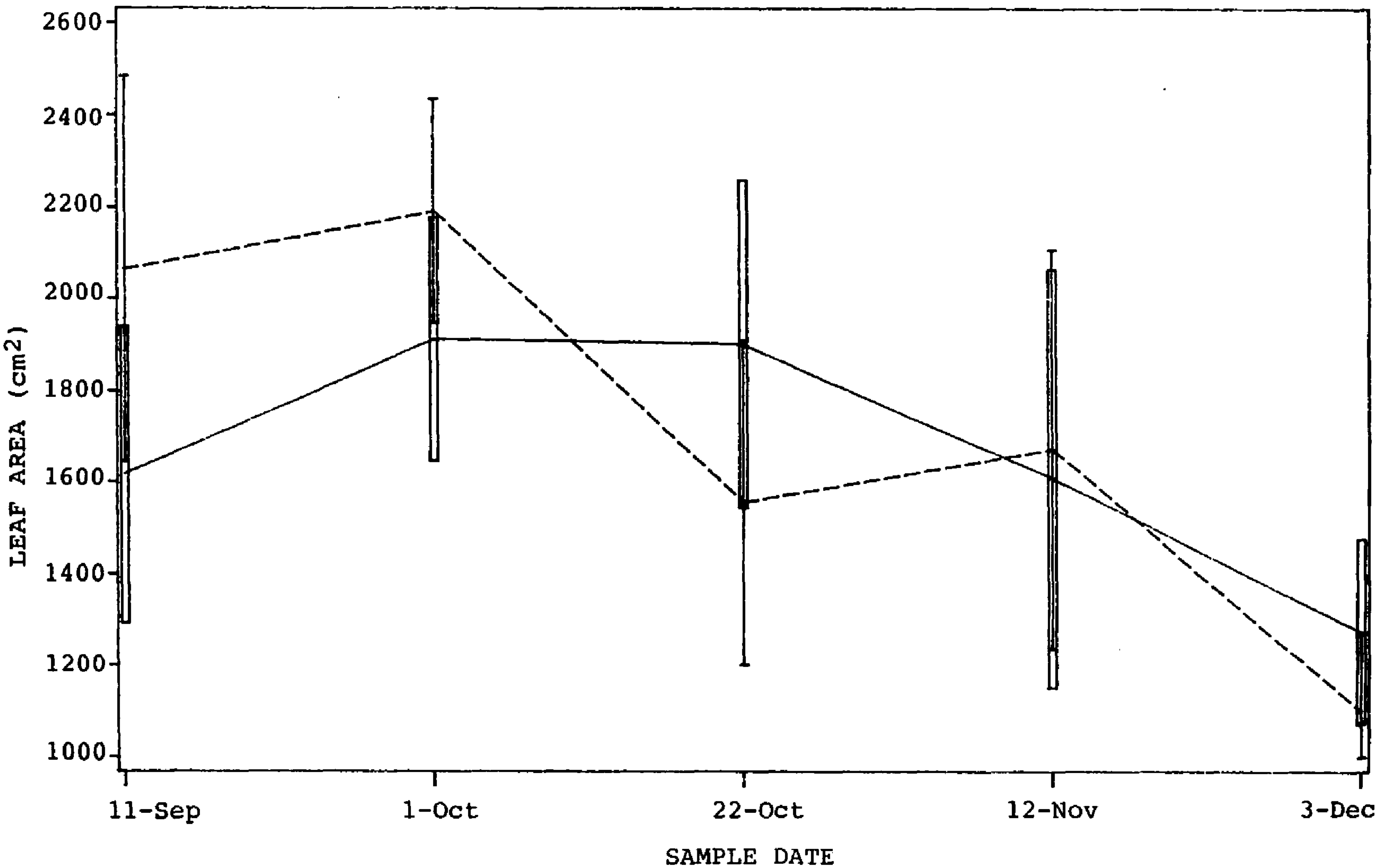

Figure 5. Mean total leaf area(cm^2) for 'Earliglow' strawberry, autumn 1986. Means of six replicates. Rowcover ——— and no cover control -------. Confidence bars STD=1.

Table 12. Crowns per plant and individual crown dry mass for 'Earliglow' strawberry, autumn 1986. Rowcover application 12 September 1986

Treatment	Sep 6	Oct 1	Oct 21	Nov 15	Dec 3	Statistical Analysis over Time
CROWNS PER PLANT(no.)						
Rowcover	1.72	1.94	2.28	2.17	2.50	Treatment NS
						Linear NS
Control	1.83	2.06	1.89	2.17	2.50	Quadratic NS
						Cubic NS
	NS[z]	NS	NS	NS	NS	Lack of Fit NS
						TreatmentxTime NS
INDIVIDUAL CROWN DRY MASS(g)						
Rowcover	1.13	1.50	1.69	1.89	1.67	Treatment NS
						Linear ***
Control	1.70	1.21	2.06	2.09	1.60	Quadratic ***
						Cubic NS
	NS	NS	NS	NS	NS	Lack of Fit NS
						TreatmentxTime NS

[z] Means within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level per F test via ANOVA.

Table 13. Stolons per plant and individual stolon dry mass for 'Earliglow' strawberry, autumn 1986. Rowcover application 12 September 1986.

Treatment	Sep 6	Oct 1	Oct 21	Nov 15	Dec 3	Statistical Analysis over Time
STOLONS PER PLANT(no.)						
Rowcover	--	--	4.17	3.83	3.56	Treatment NS
						Linear NS
Control	--	--	3.17	3.50	3.67	Quadratic NS
						Cubic NS
	--	--	NS[z]	NS	NS	Lack of Fit NS
						TreatmentxTime NS
INDIVIDUAL STOLON DRY MASS(g)						
Rowcover	--	--	0.39	0.36	0.59	Treatment NS
						Linear NS
Control	--	--	0.39	0.24	0.24	Quadratic NS
						Cubic NS
	--	--	NS	NS	NS	Lack of Fit NS
						TreatmentxTime *

[z] Means within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level per F test via ANOVA.

Table 14. Percent of dry mass for total nonstructural carbohydrates for roots, crown, leaves, petioles, stolons, and plant for 'Earliglow' strawberry, autumn 1986. Rowcover application 12 September.

Sample Date and Treatment		Total Nonstructural Carbohydrates(%)					
		Roots	Crowns	Leaves	Petioles	Stolons	Plant
6-Sep	Rowcover	5.27	6.69	7.19	11.54	^	8.00
	Control	6.87	7.63	4.78	12.18	^	6.81
		NS[z]	NS	*	NS	--	*
1-Oct	Rowcover	8.41	9.78	7.28	8.94	^	7.99
	Control	9.58	9.38	9.96	10.86	^	10.06
		NS	NS	**	NS	--	**
21-Oct	Rowcover	9.45	10.69	10.76	13.63	19.72	11.27
	Control	11.98	9.34	13.12	13.28	15.47	12.53
		NS	NS	NS	NS	**	NS
15-Nov	Rowcover	16.43	16.67	14.12	22.82	25.15	16.97
	Control	8.51	19.45	11.72	23.92	20.63	14.60
		***	NS	NS	NS	NS	**
3-Dec	Rowcover	13.60	11.02	7.48	11.21	14.55	10.49
	Control	13.49	11.38	6.22	8.57	11.12	9.61
		NS	NS	NS	NS	NS	NS
Treatment		NS	NS	NS	NS	*	NS
Time							
Linear		***	***	***	***	***	***
Quadratic		NS	***	***	***	#	***
Cubic		NS	***	***	***	#	***
Lack of Fit		NS	***	***	***	***	***
Treatment x Time		***	NS	***	**	NS	***

[z] Means within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level per F-test via ANOVA.
Significance nonestimatable due to missing values in the model.
^ Abscence of tissue or insufficient amounts for tissue analysis.

timing of cultural practices between treatments. Because the planting system required stolon removal, stolons were removed from the rowcover treatment one to two weeks before the control to facilitate timely rowcover application. Stolon removal eliminated a strong sink for translocated carbohydrates in these plants. Without this sink in rowcovered plants, nonstructural carbohydrates may have begun accumulating earlier in leaves instead of being translocated to stolons, giving the results shown in Table 14 for the 6 September samlping date.

Analysis of tissues at the second sample date showed that control leaves had a higher percent TNSC than leaves from rowcovered plants. This result is consistent with results from Experiment I. Control plants experienced lower temperatures earlier and probably began accumulating nonstructural carbohydrates in their leaves earlier in response to the rest inducing stimuli of low temperatures and short photoperiods.

On the third sample date, only stolons showed differences in percent TNSC(Table 14). Stolons in the rowcover treatment had higher percent TNSC than those in the controls. Evidence that control plants were entering rest can be seen from the elevated TNSC's in leaves on the previous sample date. Control plants may not have been efficiently translocating carbohydrates to dependent stolon plants at this time.

On the fourth sample date, roots in the rowcover treatment had higher levels of TNSC than those in the control (Table 14). These data suggest a higher rate of carbohydrate accumulation in roots of rowcovered plants at this time. The conclusion that plants in the rowcover treatment had a greater rate of accumulation is supported by the observation of higher TNSC in tissues of rowcovered plants than in the control. In control plants, maximum TNSC levels were seen at this sample date for all tissues except roots and leaves.

By the fifth sample date, there were no differences between treatments in percent TNSC in roots, and control plant roots had attained maximum levels of nonstructural carbohydrates(Table 14).

Attainment of maximum TNSC's in leaves occurred two to three weeks later in the rowcover treatment than in the control(Figure 3). These data support the interpretation that rowcovers extended the growing season and that plants sampled from the rowcover treatments and from the control were probably at different physiological stages of development on the same date.

There were no treatment differences in fructose, glucose and sucrose until the final autumn sample dates. At the final sample date in autumn, leaves on rowcovered plants had higher levels of these sugars than those on control plants(Table 15). Percent maltose was higher in leaves under the rowcover treatment only on the third sample date. In autumn, the trend was for leaf soluble sugars in rowcovered plants to increase or maintain higher levels than

Table 15. Percent of dry mass of fructose, glucose, sucrose and maltose in leaves for 'Earliglow' strawberry, autumn 1986. Rowcover application 12 September 1986.

	Sample Date					Statistical Analysis over Time	
Treatment	Sep 6	Oct 1	Oct 21	Nov 15	Dec 3		
FRUCTOSE(%)							
Rowcover	1.19	1.03	1.84	1.82	2.33	Treatment	*
						Linear	***
Control	1.22	1.21	1.73	1.67	1.73	Quadratic	NS
						Cubic	NS
	NS[z]	NS	NS	NS	*	Lack of Fit	***
						TreatmentxTime	*
GLUCOSE(%)							
Rowcover	1.15	1.02	1.73	1.76	2.25	Treatment	*
						Linear	***
Control	1.15	1.23	1.55	1.59	1.58	Quadratic	NS
						Cubic	NS
	NS	NS	NS	NS	*	Lack of Fit	**
						TreatmentxTime	**
SUCROSE(%)							
Rowcover	0.70	0.59	1.40	1.58	1.40	Treatment	**
						Linear	***
Control	0.47	0.60	1.16	1.07	0.63	Quadratic	**
						Cubic	**
	NS	NS	NS	NS	*	Lack of Fit	NS
						TreatmentxTime	NS
MALTOSE(%)							
Rowcover	0.00	0.00	0.18	0.23	0.15	Treatment	**
						Linear	***
Control	0.00	0.00	0.03	0.12	0.15	Quadratic	NS
						Cubic	***
	NS	NS	*	NS	NS	Lack of Fit	NS
						TreatmentxTime	*

[z] Means within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level per F test via ANOVA.

control plants as seen in the significant treatment differences over time in Table 15. Elevated levels of sucrose, the translocated carbohydrate in strawberry, and of glucose and fructose, constituents of sucrose, would be indicative higher metabolic activity(37). Maltose is an intermediate product of starch degradation. The increased starch concentration in leaves that occurs in late autumn and its subsequent degradation prior to translocation may be the source of the elevated maltose levels in leaves of rowcovered plants at this time.

The delay of maximum accumulation of TNSC and elevated levels of fructose, glucose and sucrose at the final sample date in rowcovered leaves are evidence that photosynthetic activity was prolonged in autumn in plants under rowcovers.

Nitrogen - During late autumn, control plants had higher nitrogen levels than rowcovered plants (Table 16). It is unclear why at the initial sample date control crowns had higher nitrogen than rowcovered crowns. It could be another artifact of the difference in stolon removal times. At the second sample date, nitrogen in petioles of rowcovered plants was higher compared to the control, but this difference was only 0.07%, which may be significant statistically but not physiologically important. The lack of clear consistent differences in percent nitrogen between treatments makes it difficult to make conclusions about nitrogen partitioning in autumn.

Carbon/Nitrogen Ratios - Differences in carbon/nitrogen

Table 16. Percent of dry mass for nitrogen in roots, crowns, leaves, petioles, stolons, and plant for 'Earliglow' strawberry, autumn 1986. Rowcover application 12 September.

Sample Date and Treatment		Nitrogen(%) Roots	Crowns	Leaves	Petioles	Stolons	Plant
6-Sep	Rowcover	1.72	1.56	2.25	1.05	^	1.84
	Control	1.73	1.77	2.32	1.05	^	1.85
		NS[z]	*	NS	NS	--	NS
1-Oct	Rowcover	1.84	1.58	2.24	0.99	^	1.83
	Control	1.70	1.58	2.24	0.93	^	1.80
		NS	NS	NS	**	--	NS
21-Oct	Rowcover	1.48	1.88	2.12	0.95	1.63	1.66
	Control	1.73	2.01	2.13	0.95	1.64	1.74
		NS	**	NS	NS	NS	NS
15-Nov	Rowcover	2.00	2.06	1.95	0.87	1.51	1.68
	Control	2.01	2.07	2.04	0.82	^	1.76
		NS	NS	NS	NS	--	*
3-Dec	Rowcover	1.87	2.15	2.04	0.82	1.53	1.66
	Control	1.98	2.26	2.18	0.85	1.35	1.83
		NS	NS	*	NS	NS	*
Treatment		NS	*	***	NS	NS	*
Time							
Linear		#	#	***	***	NS	***
Quadratic		#	#	***	NS	NS	*
Cubic		#	#	***	NS	NS	NS
Lack of Fit		#	#	NS	***	NS	NS
Treatment x Time		NS	NS	NS	*	NS	NS

[z] Means within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level per F-test via ANOVA.
Significance nonestimatable due to missing values in the model.
^ Abscence of tissue or insufficient amounts for tissue analysis.

ratio are dependent on changes in the components that constitute it. In autumn, rowcovered plants across all sampling dates had higher carbon/nitrogen ratios than controls (Table 17). On specific sample dates in autumn, there were treatment differences in roots, crowns, and leaves (Table 17), which reflected differences in TNSC(Table 14) and/or nitrogen(Table 16). Differences in the carbon/nitrogen ratio in leaves at the initial sample date were the result of higher TNSC in rowcovered plants compared to control plants. Differences at the second sample date were due to higher nitrogen in leaves in the rowcover treatment than in control plant leaves. At the final sample date differences in the carbon/nitrogen ratio were attributable to control plants having higher nitrogen levels than rowcovered plants.

A higher carbon/nitrogen ratio may not be the causal agent for more flowers and fruit in strawberry as others have concluded(44,45). The higher carbon/nitrogen ratio in this experiment may instead indicate later leaf growth. Results of this experiment contradict those for autumn of Experiment I(Table 1). In Experiment I canopy carbon/nitrogen ratio was higher for control plants than rowcovered plants, while in Experiment II canopy carbon/nitrogen ratio was higher for rowcovered plants. It was between the fourth and fifth sampling dates of Experiment II that Experiment I plants were sampled the previous year. Differences between the two experiments do not appear to be attributed to differences in sampling time. Differences in cultivars, cultural practices and growing seasons are more in likely the

Table 17. Carbon/nitrogen ratios[z] for roots, crown, leaves, petioles, stolons, and plant for 'Earliglow' strawberry, autumn 1986. Rowcover application 12 September.

Sample Date and Treatment		Carbon/Nitrogen Ratios					
		Roots	Crowns	Leaves	Petioles	Stolons	Plant
6-Sep	Rowcover	3.01	4.52	3.18	1.63	^	4.34
	Control	3.81	3.97	2.06	1.73	^	3.74
		NS[y]	NS	*	NS	--	NS
1-Oct	Rowcover	4.46	6.28	3.25	1.42	^	4.36
	Control	5.83	5.95	4.45	1.69	^	5.60
		NS	NS	*	NS	--	**
21-Oct	Rowcover	6.46	5.70	5.08	2.33	11.99	6.96
	Control	6.95	4.66	6.16	2.13	9.61	7.20
		NS	*	NS	NS	NS	NS
15-Nov	Rowcover	8.30	8.09	7.27	4.17	18.56	10.15
	Control	4.24	9.45	5.79	3.93	^	8.32
		***	NS	NS	NS	--	**
3-Dec	Rowcover	7.28	5.13	3.68	1.97	9.89	6.35
	Control	6.86	5.09	2.87	1.58	9.40	5.28
		NS	NS	*	NS	NS	NS
Treatment		*	NS	NS	NS	NS	*
Time		***	***			NS	
Linear		#	#	***	***	#	***
Quadratic		#	#	***	***	#	***
Cubic		#	#	***	***	#	***
Lack of Fit		#	#	NS	***	#	**
Treatment x Time		***	NS	***	NS	NS	***

[z] Grams total nonstructural carbohydrates per grams nitrogen.

[y] Means within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level per F-test via ANOVA.
Significance nonestimatable due to missing values in the model.
^ Abscence of tissue or insufficient amounts for tissue analysis.

practices and growing seasons are more in likely the factors contributing to the differences.

Chlorophyll Content - As in Experiment I there were no treatment differences in leaf chlorophyll concentration (Table 18).

Table 18. Chlorophyll content of leaves harvested weekly from 13-Sep to 15-Nov for 'Earliglow' strawberry, autumn 1986. Rowcover application 12 September 1986.

	Treatment and Chlorophyll Content($mg \cdot cm^{-2}$)		
Week	Rowcover	Control	Significance
First	35.22	31.83	NS
Second	38.65	38.58	NS
Third	42.68	43.89	NS
Fourth	49.34	43.72	NS
Fifth	43.62	39.55	NS
Sixth	45.97	42.73	NS
Seventh	50.57	45.82	NS
Eighth	52.82	45.65	NS
Nineth	51.14	50.03	NS
Tenth	48.55	48.01	NS
Statistical Anaylsis over Time--			
Treatments			NS
Time			***
Linear			non-estimatable
Quadratic			non-estimatable
Cubic			non-estimatable
Lack of Fit			non-estimatable
Time X Treatment			NS

[z] Within rows, nonsignficant(NS) or significantly different from the control at the 5%(*) or 1%(**) level per F-test via ANOVA.

Conclusions

In autumn, environmental modification by rowcovers had the greatest effect on leaf development, although treatment differences did not occur until the later autumn samplings. In the rowcover treatment leaf dry mass, total leaf areas, leaf number per crown and soluble sugars were higher than in control plants. Attainment of maximum specific leaf weight was delayed by three weeks in plants under rowcovers. The same trend was seen for TNSC in leaves in the rowcover treatment. Leaf nitrogen decreased in plants under row-covers. A higher carbon/nitrogen ratio for leaves in the rowcover treatment compared to those of the control was a reflection of lower leaf nitrogen in rowcovered leaves.

In addition to the direct effects on leaves by row-covers, other tissues were affected indirectly. Higher TNSC in roots of rowcovered plants compared to those in the control can only be a consequence of greater translocation of TNSC from leaves in the rowcover treatment.

Rowcover Effects on 'Earliglow' in Spring

Plant Organ Dry Mass and Number - In spring, the treatment of rowcover plus short-term mulch increased dry mass of functional leaves, petioles, stolons, total and individual crowns and total and individual stolons compared to the control(Table 19, 20 and 21). At the last sampling date there were more crowns on plants in the control than on those in the rowcover treatment(Table 20).

Table 19. Dry mass for roots, crowns, functional leaves, petioles, nonfunctional leaves, stolons, flowers and plant of 'Earliglow' strawberry, spring 1987. Rowcover removal 12 May. Winter mulch removal rowcover 27 March and control 24 April.

Sample Date and Treatment	Dry Mass(g) Roots	Crowns	Functional Leaves	Petioles	Nonfunctional Leaves	Stolons	Flowers	Plant
27-Mar								
Rowcover	6.70	4.34	4.89	1.67	13.77	1.26	^	32.63
Control	6.60	4.61	3.55	0.96	17.60	0.66	^	33.97
	NS[z]	NS	NS	*	NS	*	--	NS
15-Apr								
Rowcover	7.79	3.98	2.93	1.02	6.33	1.14	^	23.18
Control	6.93	4.17	1.37	0.57	9.05	0.34	^	22.43
	NS	NS	NS	NS	NS	NS	--	NS
6-May								
Rowcover	7.03	4.81	5.64	1.98	12.77	0.57	10.58	33.09
Control	5.79	3.55	0.92	0.27	7.31	0.07	^	17.91
	NS	NS	**	**	NS	NS	--	*
27-May								
Rowcover	4.22	5.00	7.42	3.55	1.64	0.27	11.40	23.60
Control	4.22	3.76	2.71	1.06	0.76	0.03	8.83	13.02
	NS	**	***	***	NS	NS	**	**
Treatment	NS	NS	***	***	NS	*	#	*
Time								
Linear	**	NS	*	***	***	***	#	***
Quadratic	*	NS	***	***	NS	NS	#	NS
Lack of Fit	NS	NS	NS	NS	***	NS	#	**
Treatment x Time	NS	NS	**	***	**	NS	#	*

[z] Means within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level per F-test via ANOVA.
Significance nonestimatable due to missing values in the model.
^ Abscence of tissue or insufficient amounts for tissue analysis.

Table 20. Crowns per plant and individual crown dry mass for 'Earliglow' strawberry, spring 1987. Rowcover removal 12 May. Winter mulch removal rowcover 27 March and control 24 April.

Treatment	Sample Date 27-Mar	15-Apr	6-May	27-May	Statistical Analysis over Time
CROWNS PER PLANT(no.)					
Rowcover	3.78	3.22	3.44	4.11	Treatment NS Linear NS
Control	3.94	3.22	2.61	5.17	Quadratic *** Lack of Fit NS
	NS[z]	NS	NS	*	TreatmentxTime NS
INDIVIDUAL CROWN DRY MASS(g)					
Rowcover	1.18	1.27	1.45	1.22	Treatment NS Linear NS
Control	1.20	1.30	1.40	0.73	Quadratic *** Lack of Fit *
	NS	NS	NS	**	TreatmentxTime *

[z] Means within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level per F test via ANOVA.

The decrease in dry mass from autumn to spring and the loss of treatment differences between autumn and spring for Experiment I were attributed to the exclusion of senescent nonfunctional leaves in the spring sample. In Experiment II dry mass and numbers of senescent nonfunctional leaves were recorded to determine whether they were responsible for the lack of differences between treatments in dry mass in spring. No treatment differences were found however in nonfunctional leaf dry mass or in number per crown(Tables 19 and 22).

The higher dry mass of leaves in the rowcover plus short-term mulch treatment was a result of more leaf

Table 21. Stolons per plant and individual stolon dry weights for 'Earliglow' strawberry, spring 1987. Rowcover removal 12 May. Winter mulch removal rowcover 27 March and control 24 April.

Treatment	Sample Date 27-Mar	15-Apr	6-May	27-May	Statistical Analysis over Time
STOLONS PER PLANT(no.)					
Rowcover	2.72	1.72	1.28	0.94	Treatment NS Linear ***
Control	2.61	0.78	0.17	0.28	Quadratic ** Lack of Fit NS
	NS[z]	NS	**	NS	TreatmentxTime NS
INDIVIDUAL STOLON DRY WEIGHTS(g)					
Rowcover	0.46	0.78	0.38	0.32	Treatment NS Linear NS
Control	0.27	0.46	0.41	0.17	Quadratic NS Lack of Fit NS
	*	NS	NS	**	TreatmentxTime NS

[z] Means within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level per F test via ANOVA.

numbers per plant and per crown, and greater leaf area and specific leaf weights than for control plants (Table 19 and 23). The absence of differences in leaf numbers per plant and per crown on the first two sample dates was a function of the effect of low temperature on leaf emergence(3). Higher temperatures under rowcovers eventually affected leaf emergence and the last two sample dates rowcovered plants had higher leaf numbers per crown than control plants.

By the second sample date, the loss of larger overwintered leaves in the rowcover plus short-term mulch treatment mitigated any individual leaf area differences between

Table 22. Nonfunctional leaves per plant and per crown for 'Earliglow' strawberry, spring 1987. Rowcover removal 12 May. Winter mulch removal rowcover 27 March and control 24 April.

Treatment	Sample Date 27-Mar	15-Apr	6-May	27-May	Statistical Analysis over Time	
NONFUNCTIONAL LEAVES PER PLANT(no.)						
Rowcover	11.67	5.56	11.56	2.33	Treatment	NS
					Linear	***
Control	14.17	9.11	8.28	1.72	Quadratic	NS
					Lack of Fit	***
	NS[z]	NS	NS	NS	TreatmentxTime	*
NONFUNCTIONAL LEAVES PER CROWN(no.)						
Rowcover	3.19	1.73	3.55	0.56	Treatment	NS
					Linear	***
Control	3.56	2.88	3.14	0.33	Quadratic	***
					Lack of Fit	***
	NS	NS	NS	NS	TreatmentxTime	NS

[z] Means within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level per F test via ANOVA.

treatments that were apparent at the initial spring sample date(Table 23). On the last two sample dates there were differences in individual leaf areas between treatments (Table 23). Higher temperatures under the rowcover promoted higher rate of leaf expansion than was seen in controls. Greater individual leaf area and leaf numbers in the row-cover plus early mulch removal treatment resulted in greater total leaf area for those plants than for control plants (Table 23).

For the rowcover plus short-term mulch treatment, stolon number and dry mass in spring were greater than plants in the control treatment(Table 21). It can be as-

Table 23. Leaves per plant, leaves per crown, total leaf area per plant, individual leaf area and specific leaf weight of 'Earliglow' strawberry, spring 1987. Rowcover removal 12 May. Winter mulch removal rowcover 27 March and control 24 April.

Treatment	Sample Date 27-Mar	15-Apr	6-May	27-May	Statistical[z] Analysis over Time	
LEAVES PER PLANT(no.)						
Rowcover	6.50	8.89	15.11	19.39	Treatment	*
					Linear	***
Control	5.94	6.39	6.06	17.61	Quadratic	***
					Lack of Fit	NS
	NS	NS	**	NS	TreatmentxTime	**
LEAVES PER CROWN(no.)						
Rowcover	1.76	2.84	4.62	4.73	Treatment	**
					Linear	***
Control	1.57	1.98	2.36	3.41	Quadratic	NS
					Lack of Fit	NS
	NS	NS	*	*	TreatmentxTime	*
TOTAL LEAF AREA PER PLANT(cm^2)						
Rowcover	756.02	384.28	769.77	1058.72	Treatment	***
					Linear	**
Control	492.61	225.90	157.42	562.73	Quadratic	***
					Lack of Fit	NS
	NS	NS	**	**	TreatmentxTime	*
INDIVIDUAL LEAF AREA(cm^2)						
Rowcover	116.40	43.06	50.67	56.04	Treatment	**
					Linear	***
Control	81.00	36.80	25.34	32.20	Quadratic	***
					Lack of Fit	**
	*	NS	***	*	TreatmentxTime	*
SPECIFIC LEAF WEIGHT($g \cdot cm^{-2} \cdot 10^{-3}$)						
Rowcover	6.6	7.6	7.3	7.0	Treatment	**
					Linear	NS
Control	7.3	6.2	5.5	4.7	Quadratic	NS
					Lack of Fit	NS
	NS	NS	NS	**	TreatmentxTime	*

[z] Means within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level per F test via ANOVA.

sumed that these stolons survived over the winter because environmental conditions during winter are not conducive to stolon formation and growth and that plants under rowcovers retained their stolons longer than controls. Between the last two sample dates in autumn no new stolons appeared in either treatment(Table 13) indicating that plants in both treatments had ceased stolon initiation and were entering rest.

Total Nonstructural Carbohydrate and Soluble Sugars - There was no difference in percent TNSC of nonfunctional and senescent leaves between treatments(Table 24). Rowcovers apparently had no effect on translocation of TNSC from these leaves. Rowcovers did have are affect on percent TNSC in stolons. Stolons under rowcovers had higher levels than controls(Table 24).

In spring, rowcovers markedly increased TNSC in functional leaves. Total nonstructural carbohydrates were higher on all sample dates, which explains why specific leaf weights were higher for rowcovered plants than for control plants(Table 24). However, differences in TNSC in petioles were only seen on the third and fourth sample dates. On the first two sample dates, expanding leaves were probably a strong sink for translocatable carbohydrates. At this time TNSC were probably being utilized within the leaf for early growth and expansion and were not being exported. It was not until these leaves became net exporters of carbohydrates that elevated levels of TNSC appeared in petioles.

Translocation is more sensitive to low temperatures

Table 24. Percent of dry mass for total nonstructural carbohydrates for roots, crowns, functional leaves, petioles, nonfunctional leaves, stolons, flowers and plant for 'Earliglow' strawberry, spring 1987. Rowcover removal 12 May. Winter mulch removal rowcover 27 March and control 24 April.

Sample Date and Treatment	Total Nonstructural Carbohydrates(%) Roots	Crowns	Functional Leaves	Petioles	Nonfunctional Leaves	Stolons	Flowers	Plant
27-Mar								
Rowcover	6.75	7.89	7.19	9.27	1.39	7.96	^	4.91
Control	6.16	9.26	5.13	9.34	1.83	5.62	^	4.40
	NS[z]	*	*	NS	NS	**	--	NS
15-Apr								
Rowcover	6.35	4.59	9.28	11.15	1.34	4.09	^	5.13
Control	6.20	7.25	4.98	7.95	1.23	1.60	^	4.23
	NS	***	**	NS	NS	NS	--	NS
6-May								
Rowcover	5.70	8.57	11.88	10.12	0.28	1.36	10.58	5.41
Control	3.99	5.21	7.90	6.01	0.27	^	^	2.96
	NS	**	**	**	NS	--	--	*
27-May								
Rowcover	7.42	7.90	13.28	10.28	0.66	3.07	11.40	9.67
Control	3.81	4.94	9.90	5.70	^	^	8.83	5.50
	***	**	*	**	--	--	*	***
Treatment	*	NS	***	***	NS	*	#	**
Time								
Linear	*	***	***	NS	***	***	#	***
Quadratic	NS	***	NS	NS	NS	**	#	***
Lack of Fit	NS	***	NS	NS	*	NS	#	***
Treatment x Time	*	***	NS	*	NS	NS	#	***

[z] Means within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level per F-test via ANOVA.
Significance nonestimatable due to missing values in the model.
^ Abscence of tissue or insufficient amounts for tissue analysis.

than is photosynthesis. Lower temperatures on the first two sample dates for both treatments may have restricted the translocation stream. Higher temperatures in the rowcover plus short-term mulch treatment resulted higher growth rates for these plants, increasing the demand for carbohydrates at all sinks by the final two sample dates. These conditions probably increased the level of translocatable carbohydrates, seen as TNSC, in petioles(Table 24).

Root and crown TNSC were also affected by the rowcover plus early mulch removal treatment. Total nonstructural carbohydrates in roots decreased as growth progressed(Table 24). Roots are the major storage organ for starch in strawberry. Starch and other nonstructural carbohydrates in roots are depleted as new growth and fruit development commence in spring. A similar pattern of root carbohydrate depletion was also seen in control plants. Total nonstructural carbohydrates declined slower in rowcovered plants than for controls for the 4 sampling dates and it even increased on the last sampling date(Table 24 and Figure 6). Roots are normally a source of carbohydrates for growth in early spring, but it appears that in the latter part of the sampling period in the rowcover treatment they became a sink for photosynthates. The elevated root levels of TNSC in rowcovered plants coincide with their elevated petiole levels. Petioles are the conduits for translocatable carbohydrates to nonphotosynthetic organs. Higher levels of TNSC in petioles and roots offers evidence that rowcovered plant leaves are exporting photosynthates through petioles for

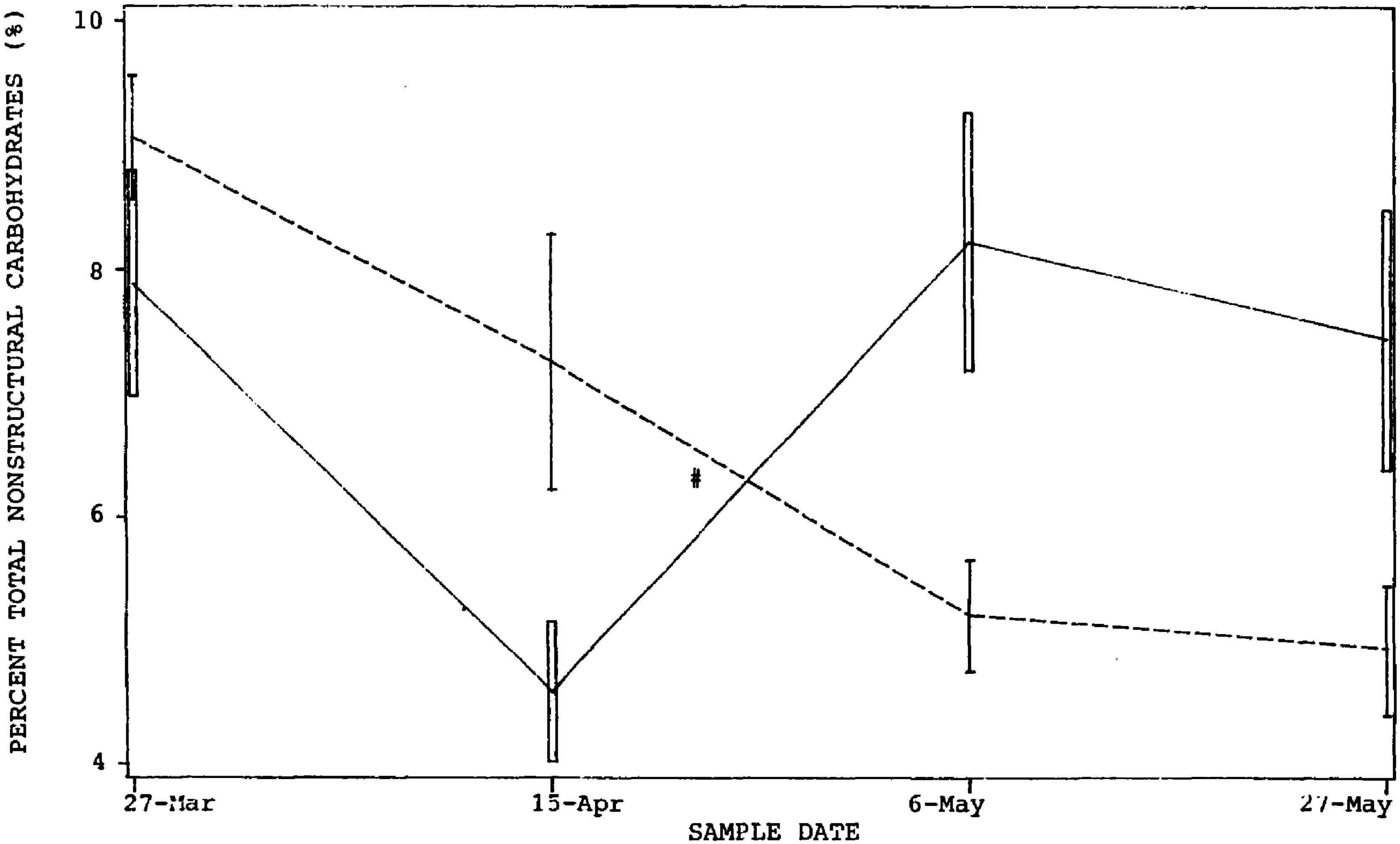

Figure 6. Mean percent total nonstructural carbohydrates of crowns for 'Earliglow' strawberry, spring 1987. Means of six replicates. Rowcovers —— and No cover control ----. Confidence bars STD=1. No cover control winter mulch removal=#.

storage in roots earlier in the growing season than in uncovered plants. The doubling of TNSC levels in roots of rowcovered plants so early in the season could possibly influence summer growth and fruiting in the following season.

Earlier growth under the rowcover plus early mulch removal treatment was also seen in differences and trends in percent TNSC in crowns. Table 24 and Figure 7 illustrate this point more clearly. The plot of percent TNSC vs Time for crowns of control plants shows a decrease throughout the spring sampling period as stored carbohydrates are being translocated to active sinks. The same plot for rowcovered plants is biphasic. The differences in the two plots resulted in a significant season by treatment interaction for percent TNSC between crowns of rowcovered and control plants.

For the first two sample dates, TNSC in crowns was higher for the control than for the rowcover plus short-term mulch treatment(Table 24). Carbohydrates stored in crowns are the most available source of energy for new growth in spring. Rowcovered plants were exposed to light and higher temperatures earlier than control plants and utilized this source of carbohydrates to support earlier and more rapid growth.

By the last two sample dates, it appears that photosynthates began moving from leaves to crowns in the rowcover treatment(Table 24 and Figure 7). The evidence for this

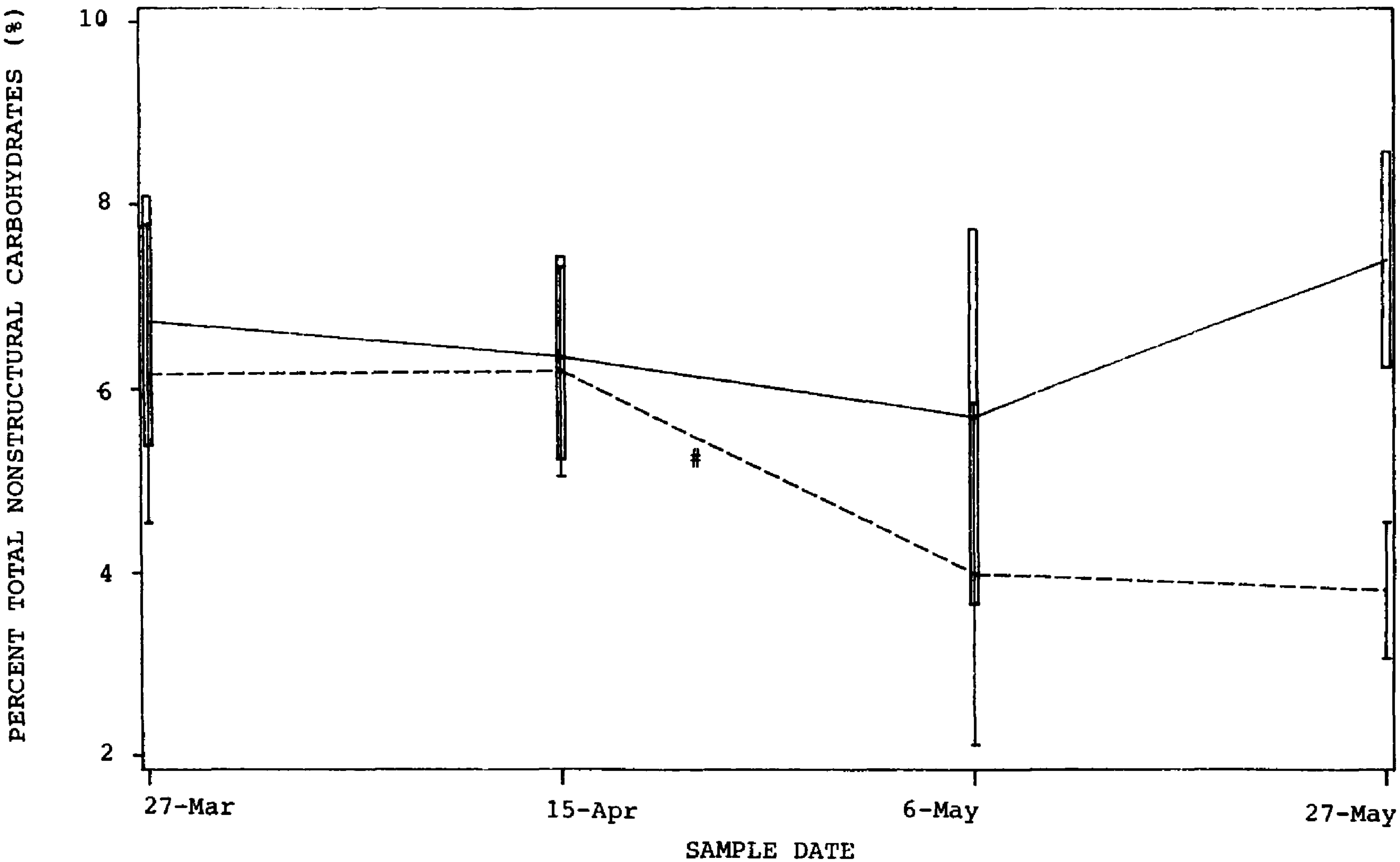

Figure 7. Mean percent total nonstructural carbohydrates of roots for 'Earliglow' strawberry, spring 1987. Means of six replicates. Rowcover —— and No cover control ----. Confidence bars STD=1. No cover control winter mulch removal=#.

conclusion is seen in the increase in percent TNSC in petioles at this time. Leaves of rowcovered plants became an apparent source of translocatable photosynthate by the third sample date. The overall effect of the rowcover was to shift the period of dependence on stored carohydrates by about three weeks earlier.

Soluble sugar concentrations offer additional evidence that leaves in rowcovered plants became functional earlier than in control plants in spring(Table 25). Fructose, glucose and sucrose were higher in leaves in the rowcover treatment on the second sample date compared to controls (Table 25). Glucose and fructose levels continued to be higher than in the controls for the remaining sample dates. A higher percentage of fructose in rowcovered leaves compared to controls was sustained only through the third sample date. There were no treatment differences for sucrose for the remaining sample dates, nor were differences seen for maltose for all sample dates. Elevated levels of glucose, fructose and sucrose in leaves in the rowcover treatment in spring are evidence of earlier photosynthetic activity in these leaves than in the leaves on control plants.

<u>Nitrogen</u> - Nitrogen is also required for growth in spring. In strawberry, primarily roots and occasionally crowns are storage sites for both nitrogen and carbohydrate. During early spring growth both are retranslocated to actively growing tissues. The rate of their depletion is dependent upon environmental conditions. If conditions are

condusive to accelerated growth, reserves will be depleted more rapidly.

Table 25. Percent of dry mass of fructose, glucose, sucrose and maltose in leaf blades of 'Earliglow' strawberry, spring 1987. Rowcover removal 12 May. Winter mulch removal rowcover 27 March and control 24 April.

Treatment	27-Mar	15-Apr	6-May	27-May	Statistical Analysis over Time	
FRUCTOSE(%)						
Rowcover	1.00	1.40	1.32	0.89	Treatment	**
					Linear	NS
Control	0.94	0.66	0.80	0.81	Quadratic	NS
					Lack of Fit	NS
	NS[z]	**	*	NS	TreatmentxTime	**
GLUCOSE(%)						
Rowcover	0.89	1.15	1.16	0.82	Treatment	**
					Linear	NS
Control	0.82	0.53	0.65	0.65	Quadratic	NS
					Lack of Fit	NS
	NS	**	**	*	TreatmentxTime	NS
SUCROSE(%)						
Rowcover	0.57	1.38	0.66	0.43	Treatment	NS
					Linear	NS
Control	0.29	0.27	0.59	0.56	Quadratic	**
					Lack of Fit	NS
	NS	***	NS	NS	TreatmentxTime	***
MALTOSE(%)						
Rowcover	0.15	0.15	0.18	0.08	Treatment	NS
					Linear	*
Control	0.12	0.15	0.21	0.02	Quadratic	***
					Lack of Fit	*
	NS	NS	NS	NS	TreatmentxTime	NS

[z] Means within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level per F test via ANOVA.

Rowcovered plants exposed to light and higher tempera-

Rowcovered plants exposed to light and higher temperatures earlier in spring began growth earlier and were found to deplete their nitrogen reserves more rapidly than control plants(Table 26). In every instance where differences between treatments occurred, whether on individual sample dates or for the entire spring sampling period, control plants had a higher percentage of nitrogen (Table 26). Most differences did not appear until the final sample date when roots, crowns, functional leaves, petioles, nonfunctional leaves, and flowers on rowcovered plants had lower levels than controls.

Carbon/Nitrogen Ratios - Rowcovered plants and in most cases individual organs had higher carbon/nitrogen ratios than control plants due to higher TNSC and lower nitrogen (Tables 24, 26 and 27). A high carbon/nitrogen ratio as discussed by Cameron and Dennis(10) in their review of the topic, is an indicator of a vegetative growth phase in a plant.

Flowers - Flowers emerged on rowcovered plants three weeks earlier than on control plants. At the final sample date, plants in both treatments were in bloom. Flowers in the rowcover plus short-term mulch treatment had higher dry mass, percent TNSC, and carbon/nitrogen ratios, and lower nitrogen than control plants(Tables 19, 24, 26, and 27). In further work with this planting Pollard (98) with this planting determined that rowcovered plants produced more flowers per truss and more trusses per crown. These increases nearly doubled flower numbers for plants in the

Table 26. Percent of dry mass for nitrogen in roots, crown, functional leaves, petioles, nonfunctional leaves, stolons, flowers, and plant for 'Earliglow' strawberry, spring 1987. Rowcover removal 12 May. Winter mulch removal rowcover 27 March and control 24 April.

Sample Date and Treatment	Nitrogen(%) Roots	Crowns	Leaves	Petioles	NF Leaves	Stolons	Flowers	Plant
27-Mar								
Rowcover	2.22	2.13	2.31	1.18	1.62	1.61	^	1.84
Control	2.12	2.21	2.41	1.22	1.76	^	^	1.91
	NS[z]	*	NS	NS	*	--	--	NS
15-Apr								
Rowcover	1.95	2.05	2.81	1.51	1.83	1.80	^	1.84
Control	2.09	2.27	2.76	1.96	1.95	1.68	^	2.09
	NS	*	NS	NS	NS	NS	--	NS
6-May								
Rowcover	1.67	1.78	2.71	1.36	1.91	1.67	3.24	1.93
Control	1.88	2.21	2.85	2.24	1.86	1.68	^	1.99
	NS	**	NS	*	NS	#	--	NS
27-May								
Rowcover	1.61	1.47	2.52	1.06	1.80	1.71	1.92	1.82
Control	1.93	1.84	3.62	1.71	2.34	2.41	2.82	2.26
	*	**	***	***	**	#	**	***
Treatment	*	***	*	***	***	NS	#	**
Time								
Linear	***	***	***	#	#	NS	#	**
Quadratic	NS	***	NS	#	#	NS	#	NS
Lack of Fit	NS	NS	NS	#	#	NS	#	**
Treatment x Time	NS	**	***	**	**	NS	#	***

z Means within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level per F-test via ANOVA.

Significance nonestimatable due to missing values in the model.

^ Abscence of tissue or insufficient amounts for tissue analysis.

Table 27. Carbon/nitrogen ratios[z] for roots, crowns, functional leaves, petioles, nonfunctional leaves, stolons, flowers and plant for 'Earliglow' strawberry, spring 1987. Rowcover removal 12 May. Winter mulch removal 27 March and control 24 April.

Sample Date and Treatment	Carbon/Nitrogen Ratios: Roots	Crowns	Functional Leaves	Petioles	Nonfunctional Leaves	Stolons	Flowers	Plant
27-Mar								
Rowcover	3.04	3.70	3.12	7.95	0.86	4.60	^	2.67
Control	2.95	4.19	2.13	7.68	1.04	^	^	2.32
	NS[y]	*	*	NS	NS	--	--	NS
15-Apr								
Rowcover	3.26	2.24	3.32	7.45	0.74	2.34	^	2.56
Control	2.96	3.20	1.83	4.31	0.65	0.87	^	2.04
	NS	*	*	NS	NS	NS	--	*
6-May								
Rowcover	3.40	4.82	4.41	7.54	0.15	0.75	3.40	2.79
Control	2.11	2.36	2.84	2.74	0.13	^	^	1.49
	NS	***	**	**	NS	--	--	*
27-May								
Rowcover	4.63	5.40	5.28	9.77	0.48	3.68	6.00	5.33
Control	2.00	2.67	2.77	3.40	^	^	3.68	2.44
	***	**	***	***	--	--		***
Treatment	**	**	***	**	NS	*	#	***
Time								
Linear	NS	NS	***	#	#	#	#	***
Quadratic	NS	***	NS	#	#	#	#	***
Lack of Fit	NS	***	**	#	#	#	#	***
Treatment x Time	**	***	**	***	NS	--	#	***

[z] Grams total nonstructural carbohydrates per grams nitrogen.
[y] Mean within columns, nonsignificant(NS) or significantly different from the control at the 5%(*), 1%(**) or 0.1%(***) level per F-test via ANOVA.
Significance nonestimatable due to missing values in the model.
^ Abscence of tissue or insufficient amounts for tissue analysis.

rowcover plus short-term mulch treatment compared to the control.

Summer Crown Evaluation - Subsequent to harvest, total and individual crown dry mass and crown numbers were determined. Dry mass of crowns in the plants under rowcover treatment remained higher than for the control for the entire period of sampling(Table 28). Although crown numbers on control plants were higher than for the rowcover treatment before harvest, there were no treatment differences after harvest. From the data presented the cultivar 'Earliglow' appears to respond to the rowcovers by producing larger but not more crowns. Cultivars vary in their ability to partition resources to yield components. Several studies have been conducted to examine how yield components differ among different cultivars and selections(48,49,50,91,120, 122). Some cultivars produce few large crowns while others produce many small crowns(121). Some cultivars produce few

Table 28. Number of individual crowns and dry mass of total crowns per plant and individual crowns per plant for 'Earliglow' strawberry after harvest, summer 1987.

Treatment	Total Crown Dry Mass(g)	Individual Crowns(no.)	Individual Crown Dry Mass(g)
Rowcover	5.64	3.93	1.44
Control	4.21	4.68	0.93
	*z	NS	**

z Means within columns, nonsignficant(NS) or significantly different from the control at the 5%(*) or 1%(**) level per F-test via ANOVA.

trusses with many flowers, while others produce many trusses with few flowers(93).

Conclusions

Exposure of strawberry plants to light and higher temperatures earlier in the spring in the rowcover plus short-term mulch treatment facilitated earlier growth and development. These treatments also increased flower numbers(98). Higher leaf numbers per plant and per crown, specific leaf weights, leaf dry weights, individual and total leaf areas and crown dry weights in rowcovered plants as compared to control plants provide evidence that rowcovers facilitated earlier growth and development.

Lower percent nitrogen in most rowcovered plant organs as compared to controls provides evidence that rowcovered plants had increased metabolic activity earlier in spring. The data confirm that plants in the rowcover treatment were consuming their nitrogen reserves earlier in the growing season to support growth and development.

Evidence of earlier metabolic activity rowcovered plants than in control plants was also provided by differences and trends in percent TNSC. Depletion of TNSC levels in roots and crowns earlier in spring in rowcovered plants as compared to control plants, shows that stored carbohydrates were being utilized earlier in the growing season. Elevated levels of TNSC in roots and crowns later in spring in rowcovered plants compared to control plants provides evidence that these plant organs were importing carbohydrates instead of exporting them for spring growth.

Elevated soluble sugar levels in rowcovered leaves as compared to control plants also provides evidence that row-cover plants were synthesizing translocatable sugars earlier and in greater quainities than control plants. The above evidence gathered in the analysis of nonstructural carbohydrates provides support for the conclusion that rowcovers and short-term mulch facilitated growth and metabolism earlier in spring.

V. SUMMARY

The effect on carbohydrate and mineral nutrient partitioning and biomass production in strawberry of modifying temperature and exposure to light with rowcovers, is summarized below:

Experiment I--'Sparkle'

1. In autumn, only the plant canopy was responsive to environmental changes induced by rowcovers.
2. In autumn, rowcovers enhanced and sustained growth longer by causing plants to partition carbohydrates to non-metabolizable forms instead of metabolizable forms which are usually accumulated as plants enter rest in autumn.
3. In spring, there were higher TNSC levels in all tissues of rowcovered plants as compared to noncovered controls.
4. The decrease of TNSC levels in control plants from autumn to spring and increase in TNSC levels in rowcovered plants from autumn to spring provides evidence that rowcovered plants accumulated and sustained more TNSC than control plants.

Experiment I--'Fern'

1. Carbohydrate and mineral nutrient partitioning and biomass production was unaffected by environmental changes induced by rowcovers.

Experiment II

1. In autumn, elevated air and soil temepratures provided by rowcovers extended the growing season and sustained leaf fusion.

2. In autumn, leaf function was sustained longer for rowcovered plants. Maximum leaf dry mass, specific leaf weight and leaf TNSC levels were attained three weeks later for rowcovered plants than for controls.

3. In spring, environmental modification with rowcovers and early mulch removal extended the season by promoting earlier leaf development and plant growth.

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APPENDIX

Table 29. Analyses of variance[z] for autumn 1986 data gathered on 'Earliglow' strawberry root, crown and canopy dry mass.

Source	df[y]	SS	Probabilty of F
Root Dry Mass			
Whole Plots			
Blocks	5	63.673	0.0490*
Treatments	1	0.730	0.6118
Error A	5	12.471	
Split Plots			
Time	4	286.459	0.0001***
Linear	(1)	176.209	0.0001***
Quadratic	(1)	76.960	0.0007***
Cubic	(1)	0.761	0.7166
Lack of Fit	(1)	32.530	0.0216*
Treatment X Time	4	4.073	0.9480
Error B	40	227.755	
Crown Dry Mass			
Whole Plots			
Blocks	5	3.377	0.1660
Treatments	1	0.310	0.3310
Error A	5	1.337	
Split Plots			
Time	4	37.623	0.0001***
Linear	(1)	29.993	0.0001***
Quadratic	(1)	7.479	0.0001***
Cubic	(1)	0.086	0.6540
Lack of Fit	(1)	0.065	0.6969
Treatment X Time	4	0.885	0.7185
Error B	40	16.879	
Canopy Dry Mass			
Whole Plots			
Blocks	5	232.820	0.0030**
Treatments	1	4.591	0.2326
Error A	5	12.453	
Split Plots			
Time	4	1416.814	0.0001***
Linear	(1)	245.560	0.0009***
Quadratic	(1)	1153.988	0.0001***
Cubic	(1)	8.332	0.5130
Lack of Fit	(1)	8.935	0.4983
Treatment X Time	4	163.165	0.0945
Error B	40	765.109	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 30. Analyses of variance[z] for autumn 1986 data gathered on 'Earliglow' strawberry leaf and petiole dry mass and crown number.

Source	df[y]	SS	Probabilty of F
Leaf Dry Mass			
Whole Plots			
Blocks	5	0.953	0.4111
Treatments	1	98.103	0.0040**
Error A	5	5.927	
Split Plots			
Time	4	715.783	0.0001***
Linear	(1)	147.135	0.0003***
Quadratic	(1)	563.897	0.0001***
Cubic	(1)	1.289	0.7141
Lack of Fit	(1)	3.462	0.5488
Treatment X Time	4	78.237	0.1035
Error B	40	378.748	
Petiole Dry Mass			
Whole Plots			
Blocks	5	29.111	0.0019**
Treatments	1	1.361	0.0687
Error A	5	1.273	
Split Plots			
Time	4	121.403	0.0001***
Linear	(1)	12.535	0.0119*
Quadratic	(1)	104.528	0.0001***
Cubic	(1)	3.067	0.1998
Lack of Fit	(1)	1.274	0.4058
Treatment X Time	4	17.137	0.0682
Error B	40	72.166	
Crown Number			
Whole Plots			
Blocks	5	0.831	0.8113
Treatments	1	0.017	0.8435
Error A	5	1.928	
Split Plots			
Time	4	3.341	0.0627
Linear	(1)	3.115	0.0044**
Quadratic	(1)	0.042	0.7271
Cubic	(1)	0.181	0.4710
Lack of Fit	(1)	0.002	0.9377
Treatment X Time	40	0.511	0.8265
Error B	40	13.704	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 31. Analyses of variance[z] for autumn 1986 data gathered on 'Earliglow' strawberry leaf number, plant dry mass and total leaf area.

Source	df[y]	SS	Probabilty of F
Leaf Number			
Whole Plots			
Blocks	5	69.683	0.4175
Treatments	1	1.350	0.7454
Error A	5	57.283	
Split Plots			
Time	4	366.937	0.0002***
Linear	(1)	151.875	0.0014**
Quadratic	(1)	197.890	0.0003***
Cubic	(1)	14.468	0.2961
Lack of Fit	(1)	2.705	0.6496
Treatment X Time	4	53.048	0.4049
Error B	40	516.237	
Plant Dry Mass			
Whole Plots			
Blocks	5	458.543	0.0108*
Treatments	1	5.785	0.4505
Error A	5	43.209	
Split Plots			
Time	4	2334.567	0.0001***
Linear	(1)	56.682	0.2701
Quadratic	(1)	2154.349	0.0001***
Cubic	(1)	10.065	0.6401
Lack of Fit	(1)	113.472	0.1215
Treatment X Time	4	269.750	0.2241
Error B	40	1813.191	
Total Leaf Area			
Whole Plots			
Blocks	5	1651156.708	0.0696
Treatments	1	15717.281	0.6722
Error A	5	389867.237	
Split Plots			
Time	4	8604317.621	0.0001***
Linear	(1)	5171697.927	0.0001***
Quadratic	(1)	2285324.812	0.0004***
Cubic	(1)	514847.129	0.0725
Lack of Fit	(1)	632447.753	0.0475*
Treatment X Time	4	2254061.186	0.0114*
Error B	40	6050220.799	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 32. Analyses of variance[z] for autumn 1986 data gathered on 'Earliglow' strawberry mean leaf area, specific leaf weight and leaves per crown.

Source	df[y]	SS	Probabilty of F
Mean Leaf Area			
Whole Plots			
Blocks	5	2010.321	0.2939
Treatments	1	113.487	0.5230
Error A	5	1204.690	
Split Plots			
Time	4	7467.904	0.0001***
Linear	(1)	4146.829	0.0001***
Quadratic	(1)	0.420	0.9647
Cubic	(1)	196.513	0.3407
Lack of Fit	(1)	3124.142	0.0004***
Treatment X Time	4	2606.438	0.0265*
Error B	40	8453.580	
Specific Leaf Weight			
Whole Plots			
Blocks	5	0.00000162	0.9125
Treatments	1	0.00000035	0.6156
Error A	5	0.00000603	
Split Plots			
Time	4	0.00008394	0.0001***
Linear	(1)	0.00001247	0.0001***
Quadratic	(1)	0.00004347	0.0001***
Cubic	(1)	0.00000641	0.0014**
Lack of Fit	(1)	0.00002159	0.0001***
Treatment X Time	4	0.00001410	0.0004***
Error B	40	0.00002187	
Leaves per Crown			
Whole Plots			
Blocks	5	7.812	0.6619
Treatments	1	0.002	0.9804
Error A	5	11.583	
Split Plots			
Time	4	180.542	0.0001***
Linear	(1)	138.079	0.0001***
Quadratic	(1)	41.905	0.0001***
Cubic	(1)	0.030	0.8902
Lack of Fit	(1)	0.528	0.5641
Treatment X Time	4	6.971	0.3620
Error B	40	62.405	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 33. Analyses of variance[z] for autumn 1986 data gathered on 'Earliglow' strawberry percent total nonstructural carbohyrates for roots, crowns and canopy.

Source	df[y]	SS	Probabilty of F
Percent Total Nonstructural Carbohydrates Roots			
Whole Plots			
Blocks	5	31.283	0.2283
Treatments	1	4.494	0.2816
Error A	5	15.432	
Split Plots			
Time	4	420.109	0.0001***
Linear	(1)	407.487	0.0001***
Quadratic	(1)	11.624	0.1102
Cubic	(1)	0.335	0.7830
Lack of Fit	(1)	0.663	0.6985
Treatment X Time	4	215.021	0.0001***
Error B	40	174.218	
Percent Total Nonstructural Carbohydrates Crowns			
Whole Plots			
Blocks	5	6.742	0.9099
Treatments	1	3.290	0.4517
Error A	5	24.714	
Split Plots			
Time	4	808.579	0.0001***
Linear	(1)	329.180	0.0001***
Quadratic	(1)	102.789	0.0001***
Cubic	(1)	199.950	0.0001***
Lack of Fit	(1)	176.660	0.0001***
Treatment X Time	4	28.978	0.1096
Error B	40	143.262	
Percent Total Nonstructural Carbohydrates Canopy			
Whole Plots			
Blocks	5	9.996	0.4678
Treatments	1	0.304	0.7021
Error A	5	9.265	
Split Plots			
Time	4	610.912	0.0001***
Linear	(1)	62.706	0.0001***
Quadratic	(1)	307.160	0.0001***
Cubic	(1)	224.620	0.0001***
Lack of Fit	(1)	16.425	0.0042**
Treatment X Time	4	46.961	0.0004***
Error B	40	71.373	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 34. Analyses of variance[z] for autumn 1986 data gathered on 'Earliglow' strawberry percent total nonstructural carbohydrate for leaves, petioles and plant.

Source	df[y]	SS	Probabilty of F
Percent Total Nonstructural Carbohydrates Leaves			
Whole Plots			
Blocks	5	13.041	0.2034
Treatments	1	0.626	0.4998
Error A	5	5.924	
Split Plots			
Time	4	450.445	0.0001***
Linear	(1)	43.609	0.0007***
Quadratic	(1)	334.396	0.0001***
Cubic	(1)	71.967	0.0001***
Lack of Fit	(1)	0.474	0.7024
Treatment X Time	4	76.954	0.0007***
Error B	40	127.994	
Percent Total Nonstructural Carbohydrates Petioles			
Whole Plots			
Blocks	5	10.906	0.8823
Treatments	1	0.279	0.8480
Error A	5	34.197	
Split Plots			
Time	4	1509.714	0.0001***
Linear	(1)	109.004	0.0001***
Quadratic	(1)	238.548	0.0001***
Cubic	(1)	1001.905	0.0001***
Lack of Fit	(1)	160.257	0.0001***
Treatment X Time	4	36.940	0.0024**
Error B	40	74.500	
Percent Total Nonstructural Carbohydrates Plant			
Whole Plots			
Blocks	5	5.140	0.3702
Treatments	1	0.942	0.4763
Error A	5	4.861	
Split Plots			
Time	4	495.189	0.0001***
Linear	(1)	171.945	0.0001***
Quadratic	(1)	163.710	0.0001***
Cubic	(1)	143.237	0.0001***
Lack of Fit	(1)	16.300	0.0001***
Treatment X Time	4	38.230	0.0001***
Error B	40	35.709	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 35. Analyses of variance[z] for autumn 1986 data gathered on 'Earliglow' strawberry percent nitrogen for roots, crowns and canopy.

Source	df[y]	SS	Probabilty of F
Percent Nitrogen Roots			
Whole Plots			
Blocks	5	0.827	0.2039
Treatments	1	0.028	0.5666
Error A	5	0.376	
Split Plots			
Time	4	1.166	0.0009***
Linear	(0)	Non-estimatible	
Quadratic	(0)	Non-estimatible	
Cubic	(0)	Non-estimatible	
Lack of Fit	(0)	Non-estimatible	
Treatment X Time	4	0.264	0.2779
Error B	37	1.841	
Percent Nitrogen Crowns			
Whole Plots			
Blocks	5	0.029	0.7169
Treatments	1	0.107	0.0221*
Error A	5	0.050	
Split Plots			
Time	4	3.217	0.0001***
Linear	(0)	Non-estimatible	
Quadratic	(0)	Non-estimatible	
Cubic	(0)	Non-estimatible	
Lack of Fit	(0)	Non-estimabible	
Treatment X Time	4	0.073	0.1262
Error B	37	0.351	
Percent Nitrogen Canopy			
Whole Plots			
Blocks	5	0.017	0.1013
Treatments	1	0.024	0.0045**
Error A	5	0.005	
Split Plots			
Time	4	0.629	0.0001***
Linear	(1)	0.540	0.0001***
Quadratic	(1)	0.046	0.0010***
Cubic	(1)	0.033	0.0047**
Lack of Fit	(1)	0.010	0.1076
Treatment X Time	4	0.016	0.3860
Error B	40	0.146	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 36. Analyses of variance[z] for autumn 1986 data gathered on 'Earliglow' strawberry percent nitrogen for leaves, petioles and plant.

Source	df[y]	SS	Probabilty of F
Percent Nitrogen Leaves			
Whole Plots			
Blocks	5	0.003	0.7450
Treatments	1	0.058	0.0008***
Error A	5	0.005	
Split Plots			
Time	4	0.654	0.0001***
Linear	(1)	0.442	0.0001***
Quadratic	(1)	0.082	0.0008***
Cubic	(1)	0.121	0.0001***
Lack of Fit	(1)	0.009	0.2328
Treatment X Time	4	0.044	0.1514
Error B	40	0.249	
Percent Nitrogen Petioles			
Whole Plots			
Blocks	5	0.034	0.3807
Treatments	1	0.004	0.4102
Error A	5	0.026	
Split Plots			
Time	40	0.390	0.0001***
Linear	(1)	0.362	0.0001***
Quadratic	(1)	0.003	0.1390
Cubic	(1)	0.00005	0.8499
Lack of Fit	(1)	0.025	0.0002***
Treatment X Time	4	0.017	0.0323*
Error B	40	0.059	
Percent Nitrogen Plant			
Whole Plots			
Blocks	5	0.047	0.3847
Treatments	1	0.058	0.0354*
Error A	5	0.035	
Split Plots			
Time	4	0.188	0.0008***
Linear	(1)	0.107	0.0007***
Quadratic	(1)	0.050	0.0165**
Cubic	(1)	0.011	0.2409
Lack of Fit	(1)	0.020	0.1198
Treatment X Time	4	0.066	0.1033
Error B	40	0.320	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 37. Analyses of variance[z] for autumn 1986 data gathered on 'Earliglow' strawberry carbon/nitrogen ratios for roots, crowns and canopy.

Source	df[y]	SS	Probabilty of F
Carbon/Nitrogen Ratio Root			
Whole Plots			
Blocks	5	8.314	0.0069**
Treatments	1	1.974	0.0111*
Error A	5	0.640	
Split Plots			
Time	4	85.063	0.0001***
Linear	(0)	Non-estimatible	
Quadratic	(0)	Non-estimatible	
Cubic	(0)	Non-estimatible	
Lack of Fit	(0)	Non-estimatible	
Treatment X Time	4	54.792	0.0001***
Error B	37	60.424	
Carbon/Nitrogen Ratio Crowns			
Whole Plots			
Blocks	5	1.854	0.9603
Treatments	1	0.282	0.7297
Error A	5	10.547	
Split Plots			
Time	4	140.232	0.0001***
Linear	(0)	Non-estimatible	
Quadratic	(0)	Non-estimatible	
Cubic	(0)	Non-estimatible	
Lack of Fit	(0)	Non-estimatible	
Treatment X Time	4	10.042	0.1039
Error B	37	44.775	
Carbon/Nitrogen Ratio Canopy			
Whole Plots			
Blocks	5	5.020	0.3616
Treatments	1	0.889	0.3167
Error A	5	3.596	
Split Plots			
Time	4	261.579	0.0001***
Linear	(1)	44.538	0.0001***
Quadratic	(1)	112.022	0.0001***
Cubic	(1)	95.455	0.0001***
Lack of Fit	(1)	9.564	0.0009***
Treatment X Time	4	17.795	0.0008***
Error B	40	29.965	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 38. Analyses of variance[z] for autumn 1986 data gathered on 'Earliglow' strawberry carbon/nitrogen ratios for leaves, petioles and plant.

Source	df[y]	SS	Probabilty of F
Carbon/Nitrogen Ratio Leaves			
Whole Plots			
Blocks	5	3.160	0.2775
Treatments	1	0.750	0.2094
Error A	5	1.808	
Split Plots			
Time	4	129.198	0.0001***
Linear	(1)	19.063	0.0001***
Quadratic	(1)	82.891	0.0001***
Cubic	(1)	26.622	0.0001***
Lack of Fit	(1)	0.623	0.3866
Treatment X Time	4	19.460	0.0007***
Error B	40	32.508	
Carbon/Nitrogen Ratio Petioles			
Whole Plots			
Blocks	5	1.242	0.3963
Treatments	1	0.137	0.4397
Error A	5	0.970	
Split Plots			
Time	4	51.039	0.0001***
Linear	(1)	8.726	0.0001***
Quadratic	(1)	8.442	0.0001***
Cubic	(1)	28.526	0.0001***
Lack of Fit	(1)	5.346	0.0001***
Treatment X Time	4	0.910	0.0618
Error B	40	3.716	
Carbon/Nitrogen Ratio Plant			
Whole Plots			
Blocks	5	2.217	0.5773
Treatments	1	2.449	0.0849
Error A	5	2.663	
Split Plots			
Time	4	195.393	0.0001***
Linear	(1)	73.109	0.0001***
Quadratic	(1)	64.359	0.0001***
Cubic	(1)	54.399	0.0001***
Lack of Fit	(1)	3.525	0.0084**
Treatment X Time	4	16.839	0.0001***
Error B	40	18.325	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 39. Analyses of variance[z] for autumn 1986 data gathered on 'Earliglow' strawberry percent soluble sugars--fructose, glucose and sucrose in leaves.

Source	df[y]	SS	Probabilty of F
Percent Fructose			
Whole Plots			
Blocks	5	0.725	0.0164*
Treatments	1	0.256	0.0111*
Error A	5	0.083	
Split Plots			
Time	4	7.515	0.0001***
Linear	(1)	6.224	0.0001***
Quadratic	(1)	0.001	0.9109
Cubic	(1)	0.220	0.0993
Lack of Fit	(1)	1.070	0.0006***
Treatment X Time	4	1.062	0.0165*
Error B	40	3.084	
Percent Glucose			
Whole Plots			
Blocks	5	0.694	0.0387*
Treatments	1	0.387	0.0103*
Error A	5	0.121	
Split Plots			
Time	4	5.865	0.0001***
Linear	(1)	5.222	0.0001***
Quadratic	(1)	0.002	0.8731
Cubic	(1)	0.128	0.1756
Lack of Fit	(1)	0.513	0.0086**
Treatment X Time	4	1.263	0.0034**
Error B	40	2.690	
Percent Sucrose			
Whole Plots			
Blocks	5	0.262	0.6666
Treatments	1	1.817	0.0049**
Error A	5	0.393	
Split Plots			
Time	4	6.162	0.0001***
Linear	(1)	3.035	0.0001***
Quadratic	(1)	1.397	0.0029**
Cubic	(1)	1.301	0.0039**
Lack of Fit	(1)	0.430	0.0862
Treatment X Time	4	1.087	0.1196
Error B	40	5.552	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 40. Analyses of variance[z] for autumn 1986 data gathered on 'Earliglow' strawberry percent maltose in leaves, starch and glucose percent of total nonstructural carbohydrate(TNSC) in leaves.

Source	df[y]	SS	Probabilty of F
Percent Maltose			
Whole Plots			
Blocks	5	0.005	0.8654
Treatments	1	0.054	0.0071**
Error A	5	0.014	
Split Plots			
Time	4	0.291	0.0001***
Linear	(1)	0.220	0.0001***
Quadratic	(1)	0.014	0.0576
Cubic	(1)	0.057	0.0003***
Lack of Fit	(1)	0.001	0.6459
Treatment X Time	4	0.053	0.0132*
Error B	40	0.146	
Starch Percent of TNSC			
Whole Plots			
Blocks	5	540.146	0.4975
Treatments	1	300.664	0.1551
Error A	5	536.920	
Split Plots			
Time	4	14141.191	0.0001***
Linear	(1)	3269.446	0.0001***
Quadratic	(1)	9275.378	0.0001***
Cubic	(1)	274.972	0.1461
Lack of Fit	(1)	1321.394	0.0023**
Treatment X Time	4	1618.858	0.0217*
Error B	40	5006.346	
Glucose Percent of TNSC			
Whole Plots			
Blocks	5	113.364	0.3163
Treatments	1	5.393	0.5678
Error A	5	72.207	
Split Plots			
Time	4	2316.956	0.0001***
Linear	(1)	322.903	0.0006***
Quadratic	(1)	1744.849	0.0001***
Cubic	(1)	105.080	0.0400*
Lack of Fit	(1)	144.124	0.0172*
Treatment X Time	4	247.522	0.0468*
Error B	40	932.312	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 41. Analyses of variance[z] for autumn 1986 data gathered on 'Earliglow' strawberry fructose, sucrose and maltose percent of total nonstructural carbohydrates(TNSC) in leaves.

Source	df[y]	SS	Probabilty of F
Fructose Percent of TNCS			
Whole Plots			
Blocks	5	136.274	0.2657
Treatments	1	0.134	0.9285
Error A	5	75.362	
Split Plots			
Time	4	2737.200	0.0001***
Linear	(1)	415.453	0.0005***
Quadratic	(1)	1991.247	0.0001***
Cubic	(1)	94.345	0.0766
Lack of Fit	(1)	236.155	0.0064**
Treatment X Time	4	262.464	0.0756
Error B	40	1142.103	
Sucrose Percent of TNSC			
Whole Plots			
Blocks	5	25.300	0.7304
Treatments	1	165.162	0.0079**
Error A	5	45.232	
Split Plots			
Time	4	322.416	0.0028**
Linear	(1)	167.148	0.0029**
Quadratic	(1)	83.705	0.0307*
Cubic	(1)	7.071	0.5186
Lack of Fit	(1)	64.492	0.0562
Treatment X Time	4	86.652	0.2866
Error B	40	666.785	
Maltose Percent of TNSC			
Whole Plots			
Blocks	5	1.738	0.7001
Treatments	1	3.238	0.0630
Error A	5	2.852	
Split Plots			
Time	4	36.796	0.0001***
Linear	(1)	34.790	0.0001***
Quadratic	(1)	0.585	0.2813
Cubic	(1)	0.5221	0.3085
Lack of Fit	(1)	0.898	0.1836
Treatment X Time	4	4.231	0.0916
Error B	40	19.624	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 42. Analyses of variance[z] for autumn 1986 data gathered on 'Earliglow' strawberry individual crown dry mass and stolon dry mass and number.

Source	df[y]	SS	Probabilty of F
Individual Crown Dry Mass			
Whole Plots			
Blocks	5	0.430	0.3893
Treatments	1	0.170	0.1687
Error A	5	0.330	
Split Plots			
Time	4	5.221	0.0001***
Linear	(1)	2.061	0.0003***
Quadratic	(1)	3.060	0.0001***
Cubic	(1)	0.014	0.7500
Lack of Fit	(1)	0.086	0.4283
Treatment X Time	4	0.499	0.4571
Error B	40	5.379	
Stolon Dry Mass			
Whole Plots			
Blocks	5	5.255	0.2544
Treatments	1	4.666	0.0345*
Error A	5	2.810	
Split Plots			
Time	2	0.742	0.4436
Linear	(1)	0.022	0.8250
Lack of Fit	(1)	0.720	0.2145
Treatment X Time	2	1.046	0.3237
Error B	20	8.763	
Stolon Number			
Whole Plots			
Blocks	5	13.025	0.2572
Treatments	1	1.494	0.3497
Error A	5	7.025	
Split Plots			
Time	4	0.025	0.9893
Linear	(1)	0.019	0.9003
Lack of Fit	(1)	0.006	0.9423
Treatment X Time	4	1.877	0.4562
Error B	40	22.988	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 43. Analyses of variance[z] for autumn 1986 data gathered on 'Earliglow' strawberry stolon--individual dry mass, percent total nonstructural carbohydrates, percent nitrogen and carbon/nitrogen ratios.

Source	df[y]	SS	Probabilty of F
Stolon Individual Dry Mass			
Whole Plots			
Blocks	5	0.382	0.1868
Treatments	1	0.215	0.0505
Error A	5	0.164	
Split Plots			
Time	2	0.091	0.2036
Linear	(1)	0.002	0.7809
Lack of Fit	(1)	0.089	0.0813
Treatment X Time	2	0.190	0.4600
Error B	20	0.527	
Percent Total Nonstructural Carbohydrates Stolon			
Whole Plots			
Blocks	5	66.290	0.5859
Treatments	1	148.799	0.0292*
Error A	5	81.299	
Split Plots			
Time	2	607.508	0.0001***
Linear	(1)	135.803	0.0005***
Lack of Fit	(1)	471.706	0.0001***
Treatment X Time	2	1.918	0.8868
Error B	20	158.738	
Percent Nitrogen Stolons			
Whole Plots			
Blocks	5	0.049	0.5790
Treatments	1	0.016	0.3892
Error A	5	0.027	
Split Plots			
Time	2	0.078	0.2291
Linear	(0)	Non-estimatible	
Lack of Fit	(0)	Non-estimatible	
Treatment X Time	2	0.020	0.3511
Error B	20	0.071	
Carbon/Nitrogen Ratio Stolon			
Whole Plots			
Blocks	5	23.927	0.2684
Treatments	1	1.722	0.4536
Error A	5	4.047	
Split Plots			
Time	2	60.093	0.0442*
Linear	(0)	Non-estimatible	
Lack of Fit	(0)	Non-estimatible	
Treatment X Time	2	6.426	0.2737
Error B	20	15.999	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 44. Analyses of variance[z] for spring 1987 data gathered on 'Earliglow' strawberry root, crown and canopy dry mass.

Source	df[y]	SS	Probabilty of F
Root Dry Mass			
Whole Plots			
Blocks	5	8.363	0.7276
Treatments	1	3.615	0.3198
Error A	5	14.829	
Split Plots			
Time	3	66.201	0.0070**
Linear	(1)	40.860	0.0053**
Quadratic	(1)	25.240	0.0248*
Lack of Fit	(1)	0.102	0.8816
Treatment X Time	3	3.221	0.8694
Error B	30	135.523	
Crown Dry Mass			
Whole Plots			
Blocks	5	0.339	0.9971
Treatments	1	3.135	0.1778
Error A	5	6.381	
Split Plots			
Time	3	1.215	0.7679
Linear	(1)	0.017	0.9013
Quadratic	(1)	1.0.94	0.3189
Lack of Fit	(1)	0.104	0.7566
Treatment X Time	3	6.596	0.1259
Error B	30	31.943	
Canopy Dry Mass			
Whole Plots			
Blocks	5	7.595	0.5708
Treatments	1	234.334	0.0001***
Error A	5	9.983	
Split Plots			
Time	3	125.899	0.0001***
Linear	(1)	29.286	0.0046**
Quadratic	(1)	92.769	0.0001***
Lack of Fit	(1)	3.845	0.2754
Treatment X Time	3	69.503	0.0007***
Error B	30	393.456	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 45. Analyses of variance[z] for spring 1987 data gathered on 'Earliglow' strawberry leaves, petiole and plant dry mass.

Source	df[y]	SS	Probabilty of F
Leaves Dry Mass			
Whole Plots			
Blocks	5	2.671	0.7214
Treatments	1	113.960	0.0001***
Error A	5	4.653	
Split Plots			
Time	3	56.581	0.0001***
Linear	(1)	8.091	0.0412*
Quadratic	(1)	44.647	0.0001***
Lack of Fit	(1)	3.842	0.1519
Treatment X Time	3	32.057	0.0025**
Error B	30	53.317	
Petiole Dry Mass			
Whole Plots			
Blocks	5	1.513	0.2996
Treatments	1	21.462	0.0001***
Error A	5	0.921	
Split Plot			
Time	3	15.291	0.0001***
Linear	(1)	6.590	0.0001***
Quadratic	(1)	8.701	0.0001***
Lack of Fit	(1)	0.0000004	0.9989
Treatment X Time	3	7.925	0.0001***
Error B	30	6.593	
Plant Dry Mass			
Whole Plots			
Blocks	5	45.411	0.9097
Treatments	1	474.769	0.0129*
Error A	5	166.261	
Split Plots			
Time	3	1423.984	0.0001***
Linear	(1)	1071.432	0.0001***
Quadratic	(1)	32.802	0.4134
Lack of Fit	(1)	319.750	0.0147*
Treatment X Time	3	558.796	0.0181*
Error B	30	1430.601	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 46. Analyses of variance[z] for spring 1987 data gathered on 'Earliglow' strawberry stolon, nonfunctional leaf and individual crown dry mass.

Source	df[y]	SS	Probabilty of F
Stolon Dry Mass			
Whole Plots			
Blocks	5	0.770	0.6995
Treatments	1	3.440	0.0141*
Error A	5	1.261	
Split Plots			
Time	3	4.944	0.0001***
Linear	(1)	4.816	0.0001***
Quadratic	(1)	0.008	0.8248
Lack of Fit	(1)	0.121	0.3793
Treatment X Time	3	0.494	0.3713
Error B	30	4.560	
Nonfunctional Leaf Dry Mass			
Whole Plots			
Blocks	5	10.397	0.9890
Treatments	1	0.030	0.9717
Error A	5	109.309	
Split Plots			
Time	3	1293.798	0.0001***
Linear	(1)	1013.060	0.0001***
Quadratic	(1)	2.153	0.6650
Lack of Fit	(1)	278.584	0.0001***
Treatment X Time	3	157.936	0.0085**
Error B	30	337.767	
Individual Crown Dry Mass			
Whole Plots			
Blocks	5	0.418	0.2211
Treatments	1	0.179	0.0887
Error A	5	0.201	
Split Plots			
Time	3	1.272	0.0003***
Linear	(1)	0.144	0.1024
Quadratic	(1)	0.877	0.0002***
Lack of Fit	(1)	0.252	0.0334*
Treatment X Time	3	0.547	0.0246*
Error B	30	1.517	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 47. Analyses of variance[z] for spring 1987 data gathered on 'Earliglow' strawberry individual stolon dry mass, leaves per crown and nonfuctional leaves per crown.

Source	df[y]	SS	Probabilty of F
Individual Stolon Dry Mass			
Whole Plots			
Blocks	5	0.384	0.5160
Treatments	1	0.242	0.1420
Error A	5	0.398	
Split Plots			
Time	3	0.682	0.0980
Linear	(0)	Non-estimatible	
Quadratic	(0)	Non-estimatible	
Lack of Fit	(0)	Non-estimatible	
Treatment X Time	3	0.082	0.8343
Error B	22	2.108	
Leaves per Crown			
Whole Plots			
Blocks	5	2.088	0.6517
Treatments	1	16.076	0.0036**
Error A	5	3.015	
Split Plots			
Time	3	41.782	0.0001***
Linear	(1)	41.267	0.0001***
Quadratic	(1)	0.088	0.6820
Lack of Fit	(1)	0.427	0.3694
Treatment X Time	3	96.770	0.0113*
Error B	30	15.437	
Nonfunctioal Leaves per Crown			
Whole Plots			
Blocks	5	3.803	0.3560
Treatments	1	0.564	0.3526
Error A	5	2.686	
Split Plots			
Time	3	67.951	0.0001***
Linear	(1)	35.997	0.0001***
Quadratic	(1)	10.049	0.0001***
Lack of Fit	(1)	21.905	0.0001***
Treatment X Time	3	4.435	0.0554
Error B	30	15.694	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 48. Analyses of variance[z] for spring 1987 data gathered on 'Earliglow' strawberry crown, leaf and stolon number.

Source	df[y]	SS	Probabilty of F
Crown Number			
Whole Plots			
Blocks	5	1.132	0.9628
Treatments	1	0.113	0.7820
Error A	5	6.650	
Split Plots			
Time	3	19.044	0.0003***
Linear	(1)	2.745	0.0649
Quadratic	(1)	15.188	0.0001***
Lack of Fit	(1)	1.112	0.2321
Treatment X Time	3	5.396	0.0868
Error B	30	22.421	
Leaf Number			
Whole Plots			
Blocks	5	13.519	0.9476
Treatments	1	1444.677	0.0216*
Error A	5	66.630	
Split Plots			
Time	3	1083.231	0.0001***
Linear	(1)	949.363	0.0001***
Quadratic	(1)	126.750	0.0005***
Lack of Fit	(1)	7.119	0.3597
Treatment X Time	3	130.491	0.0048**
Error B	30	246.778	
Stolon Number			
Whole Plots			
Blocks	5	3.493	0.7601
Treatments	1	6.021	0.0898
Error A	5	6.826	
Split Plots			
Time	3	32.137	0.0001***
Linear	(1)	26.889	0.0001***
Quadratic	(1)	5.113	0.0077**
Lack of Fit	(1)	0.134	0.6471
Treatment X Time	3	1.729	0.4425
Error B	30	18.772	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 49. Analyses of variance[z] for spring 1987 data gathered on 'Earliglow' strawberry total leaf area per plant, mean leaf area and specific leaf weight.

Source	df[y]	SS	Probabilty of F
<u>Total Leaf Area</u>			
Whole Plots			
Blocks	5	117819.212	0.4018
Treatments	1	1755985.052	0.0002***
Error A	5	93237.524	
Split Plots			
Time	3	1691312.567	0.0001***
Linear	(1)	309088.950	0.0057**
Quadratic	(1)	1332075.478	0.0001***
Lack of Fit	(1)	50148.139	0.2401
Treatment X Time	3	390379.851	0.0217*
Error B	30	1047561.233	
<u>Mean Leaf Area</u>			
Whole Plots			
Blocks	5	1432.760	0.5358
Treatments	1	6179.476	0.0067**
Error A	5	1559.083	
Split Plots			
Time	3	30537.146	0.0001***
Linear	(1)	16471.447	0.0001***
Quadratic	(1)	12635.349	0.0001***
Lack of Fit	(1)	1430.351	0.0018**
Treatment X Time	3	1314.870	0.0245*
Error B	30	3645.022	
<u>Specific Leaf Weight</u>			
Whole Plots			
Blocks	5	0.000005	0.5395
Treatments	1	0.000017	0.0100**
Error A	5	0.000005	
Split Plots			
Time	3	0.000008	0.1622
Linear	(1)	0.000008	0.0331*
Quadratic	(1)	0.0000006	0.5204
Lack of Fit	(1)	0.0000001	0.7680
Treatment X Time	3	0.000016	0.0278*
Error B	30	0.000045	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 50. Analyses of variance[z] for Spring 1987 data gathered on 'Earliglow' strawberry nonfunctional leaf number per plant, starch percent and glucose percent of total non-structural carbohydrates(TNSC).

Source	df[y]	SS	Probabilty of F
<u>Nonfunctional Leaf Number</u>			
Whole Plots			
Blocks	5	15.928	0.9518
Treatments	1	3.521	0.6625
Error A	5	81.965	
Split Plots			
Time	3	767.396	0.0001***
Linear	(1)	543.004	0.0001***
Quadratic	(1)	15.947	0.1944
Lack of Fit	(1)	208.445	0.0001***
Treatment X Time	3	86.507	0.0379*
Error B	30	271.569	
<u>Starch Percent of TNSC</u>			
Whole Plots			
Blocks	5	255.994	0.1633
Treatments	1	4.147	0.6683
Error A	5	1000.255	
Split Plots			
Time	3	3431.589	0.0001***
Linear	(1)	3089.066	0.0001***
Quadratic	(1)	234.090	0.0657
Lack of Fit	(1)	108.433	0.2035
Treatment X Time	3	514.804	0.0651
Error B	30	1924.734	
<u>Glucose Percent of TNSC</u>			
Whole Plots			
Blocks	5	26.512	0.8355
Treatments	1	0.013	0.9763
Error A	5	67.387	
Split Plots			
Time	3	414.41	0.0001***
Linear	(1)	413.673	0.0001***
Quadratic	(1)	0.084	0.9249
Lack of Fit	(1)	0.654	0.7925
Treatment X Time	3	54.412	0.124
Error B	30	278.615	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 51. Analyses of variance[z] for spring 1987 data gathered on 'Earliglow' strawberry fructose, sucrose and maltose percent of total nonstructural carbohydrates(TNSC).

Source	df[y]	SS	Probabilty of F
Fructose Percent of TNSC			
Whole Plots			
Blocks	5	36.583	0.8245
Treatments	1	4.592	0.6333
Error A	5	89.079	
Split Plots			
Time	3	552.992	0.0001***
Linear	(1)	539.894	0.0001***
Quadratic	(1)	4.575	0.5476
Lack of Fit	(1)	8.523	0.4129
Treatment X Time	3	66.706	0.1687
Error B	30	370.896	
Sucrose Percent of TNSC			
Whole Plots			
Blocks	5	56.394	0.7993
Treatments	1	44.585	0.2398
Error A	5	125.325	
Split Plots			
Time	3	209.752	0.0268**
Linear	(1)	55.811	0.1041
Quadratic	(1)	99.765	0.0326*
Lack of Fit	(1)	54.175	0.1091
Treatment X Time	3	256.833	0.0121*
Error B	30	595.848	
Maltose Percent of TNSC			
Whole Plots			
Blocks	5	16.024	0.4098
Treatments	1	5.679	0.1985
Error A	5	12.931	
Split Plots			
Time	3	33.004	0.0008***
Linear	(1)	20.559	0.0009***
Quadratic	(1)	11.989	0.0084**
Lack of Fit	(1)	0.457	0.5860
Treatment X Time	3	8.229	0.1645
Error B	30	45.173	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 52. Analyses of variance[z] for spring 1987 data gathered on 'Earliglow' strawberry percent soluble sugars--fructose, glucose and sucrose in leaves.

Source	df[y]	SS	Probabilty of F
Percent Fructose			
Whole Plots			
Blocks	5	0.207	0.7311
Treatments	1	1.477	0.0067**
Error A	5	0.372	
Split Plots			
Time	3	0.312	0.1822
Linear	(1)	0.061	0.3216
Quadratic	(1)	0.225	0.0624
Lack of Fit	(1)	0.026	0.5193
Treatment X Time	3	1.014	0.0035**
Error B	30	1.802	
Percent Glucose			
Whole Plots			
Blocks	5	0.153	0.7425
Treatments	1	1.399	0.0042**
Error A	5	0.284	
Split Plots			
Time	3	0.173	0.3146
Linear	(1)	0.049	0.3153
Quadratic	(1)	0.068	0.2388
Lack of Fit	(1)	0.057	0.2792
Treatment X Time	3	0.641	0.0094**
Error B	30	1.403	
Percent Sucrose			
Whole Plots			
Blocks	5	0.472	0.7820
Treatments	1	1.236	0.0545
Error A	5	0.989	
Split Plots			
Time	3	1.236	0.0177*
Linear	(1)	0.003	0.8656
Quadratic	(1)	0.928	0.0057**
Lack of Fit	(1)	0.305	0.0983
Treatment X Time	3	2.698	0.0003***
Error B	30	3.143	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 53. Analyses of variance[z] for spring 1987 data gathered on 'Earliglow' strawberry percent maltose in leaves, percent total nonstructural carbohydrates in roots and crowns.

Source	df[y]	SS	Probabilty of F
Percent Maltose			
Whole Plots			
Blocks	5	0.093	0.2023
Treatments	1	0.003	0.5946
Error A	5	0.042	
Split Plots			
Time	3	0.143	0.0004***
Linear	(1)	0.030	0.0303*
Quadratic	(1)	0.082	0.0008***
Lack of Fit	(1)	0.030	0.0303*
Treatment X Time	3	0.014	0.5219
Error B	30	0.176	
Percent Total Nonstructural Carbohydrates Roots			
Whole Plots			
Blocks	5	9.091	0.5236
Treatments	1	27.543	0.0128*
Error A	5	9.611	
Split Plots			
Time	3	19.200	0.0470*
Linear	(1)	9.322	0.0458*
Quadratic	(1)	2.736	0.2678
Lack of Fit	(1)	7.142	0.0781
Treatment X Time	3	21.540	0.0321*
Error B	30	64.400	
Percent Total Nonstructural Carbohydrates Crowns			
Whole Plots			
Blocks	5	3.927	0.4720
Treatments	1	3.956	0.0681
Error A	5	3.676	
Split Plots			
Time	3	47.790	0.0001***
Linear	(1)	18.161	0.0001***
Quadratic	(1)	14.257	0.0004***
Lack of Fit	(1)	15.372	0.0002***
Treatment X Time	3	83.285	0.0001***
Error B	30	26.639	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 54. Analyses of variance[z] for spring 1987 data gathered on 'Earliglow' strawberry percent total nonstructural carbohydrates in canopy, leaves and petioles.

Source	df[y]	SS	Probabilty of F
Percent Total Nonstructural Carbohydrates Canopy			
Whole Plots			
Blocks	5	10.269	0.4165
Treatments	1	131.976	0.0003***
Error A	5	8.420	
Split Plots			
Time	3	96.702	0.0001***
Linear	(1)	95.657	0.0001***
Quadratic	(1)	0.066	0.8192
Lack of Fit	(1)	0.979	0.3805
Treatment X Time	3	10.671	0.0524
Error B	30	37.087	
Percent Total Nonstructural Carbohydrates Leaves			
Whole Plots			
Blocks	5	3.673	0.8536
Treatments	1	141.453	0.0004***
Error A	5	10.063	
Split Plots			
Time	3	224.409	0.0001***
Linear	(1)	217.970	0.0001***
Quadratic	(1)	1.577	0.2682
Lack of Fit	(1)	4.862	0.0568
Treatment X Time	3	8.885	0.0884
Error B	30	37.175	
Percent Total Nonstructural Carbohydrates Petioles			
Whole Plots			
Blocks	5	72.808	0.0192*
Treatments	1	104.843	0.0006**
Error A	5	8.987	
Split Plots			
Time	3	23.868	0.1202
Linear	(1)	17.604	0.0389*
Quadratic	(1)	0.310	0.7763
Lack of Fit	(1)	5.954	0.2189
Treatment X Time	3	39.607	0.0275*
Error B	30	113.251	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 55. Analyses of variance[z] for spring 1987 data gathered on 'Earliglow' strawberry percent total nonstructural carbohydrates in nonfunctional(NF) leaves, stolons and plant.

Source	df[y]	SS	Probabilty of F
Percent Total Nonstructural Carbohydrates NF Leaves			
Whole Plots			
Blocks	5	0.551	0.8857
Treatments	1	0.087	0.6398
Error A	5	1.758	
Split Plots			
Time	3	16.370	0.0001***
Linear	(1)	14.087	0.0001***
Quadratic	(1)	0.417	0.2290
Lack of Fit	(1)	1.866	0.0144*
Treatment X Time	3	1.830	0.1079
Error B	30	8.293	
Percent Total Nonstructural Carbohydrates Stolons			
Whole Plots			
Blocks	5	22.494	0.5728
Treatments	1	64.380	0.0178*
Error A	5	161.508	
Split Plots			
Time	3	262.888	0.0001***
Linear	(1)	192.873	0.0001***
Quadratic	(1)	69.096	0.0012**
Lack of Fit	(1)	0.919	0.6825
Treatment X Time	3	4.530	0.8390
Error B	30	161.508	
Percent Total Nonstructural Carbohydrates Plant			
Whole Plots			
Blocks	5	2.161	0.8211
Treatments	1	48.098	0.0010**
Error A	5	5.196	
Split Plots			
Time	3	87.179	0.0001***
Linear	(1)	41.194	0.0001***
Quadratic	(1)	34.211	0.0001***
Lack of Fit	(1)	11.774	0.0001***
Treatment X Time	3	25.061	0.0001***
Error B	30	16.420	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 56. Analyses of variance[z] for spring 1987 data gathered on 'Earliglow' strawberry percent nitrogen for roots, crowns and canopy.

Source	df[y]	SS	Probabilty of F
Percent Nitrogen Roots			
Whole Plots			
Blocks	5	0.026	0.9436
Treatments	1	0.248	0.0256*
Error A	5	0.125	
Split Plots			
Time	3	1.387	0.0001***
Linear	(1)	1.260	0.0001***
Quadratic	(1)	0.061	0.1914
Lack of Fit	(1)	0.066	0.1754
Treatment X Time	3	0.296	0.0514
Error B	30	1.023	
Percent Nitrogen Crowns			
Whole Plots			
Blocks	5	0.012	0.9307
Treatments	1	0.908	0.0002***
Error A	5	0.052	
Split Plots			
Time	3	2.109	0.0001***
Linear	(1)	1.782	0.0001***
Quadratic	(1)	0.327	0.0001***
Lack of Fit	(1)	0.00002	0.9704
Treatment X Time	3	0.217	0.0013**
Error B	30	0.320	
Percent Nitrogen Canopy			
Whole Plots			
Blocks	5	1.697	0.0514
Treatments	1	1.483	0.0055**
Error A	5	0.341	
Split Plots			
Time	3	1.444	0.0008***
Linear	(1)	1.079	0.0003***
Quadratic	(1)	0.243	0.0646
Lack of Fit	(1)	0.123	0.1828
Treatment X Time	3	1.727	0.0003***
Error B	30	1.979	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 57. Analyses of variance[z] for spring 1987 data gathered on 'Earliglow' strawberry percent nitrogen leaves, petioles and nonfuctional leaves.

Source	df[y]	SS	Probabilty of F
Percent Nitrogen Leaves			
Whole Plots			
Blocks	5	0.278	0.6356
Treatments	1	1.229	0.0104*
Error A	5	0.385	
Split Plots			
Time	3	3.087	0.0001***
Linear	(1)	2.714	0.0001***
Quadratic	(1)	0.055	0.4353
Lack of Fit	(1)	0.318	0.0660
Treatment X Time	3	2.437	0.0002***
Error B	30	2.623	
Percent Nitrogen Petiole			
Whole Plots			
Blocks	5	0.099	0.8226
Treatments	1	5.678	0.0007***
Error A	5	0.238	
Split Plots			
Time	3	2.530	0.0001***
Linear	(0)	Non-estimatible	
Quadratic	(0)	Non-estimatible	
Lack of Fit	(0)	Non-estimatible	
Treatment X Time	3	0.951	0.0011**
Error B	28	1.247	
Percent Nitrogen Nonfunctional Leaves			
Whole Plots			
Blocks	5	0.438	0.0012**
Treatments	1	0.393	0.0001***
Error A	5	0.016	
Split Plots			
Time	3	0.823	0.0002***
Linear	(0)	Non-estimatible	
Quadratic	(0)	Non-estimatible	
Lack of Fit	(0)	Non-estimatible	
Treatment X Time	3	0.470	0.0052**
Error B	28	0.833	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 58. Analyses of variance[z] for spring 1987 data gathered on 'Earliglow' strawberry percent nitrogen for stolons and whole plant, and carbon/nitrogen ratios for roots.

Source	df[y]	SS	Probabilty of F
Percent Nitrogen Stolons			
Whole Plots			
Blocks	5	0.059	0.8808
Treatments	1	0.133	0.1589
Error A	5	0.114	
Split Plots			
Time	3	0.073	0.7276
Linear	(0)	Non-estimatible	
Quadratic	(0)	Non-estimatible	
Lack of Fit	(0)	Non-estimatible	
Treatment X Time	0	0.000	---
Error B	8	0.439	
Percent Nitrogen Whole Plant			
Whole Plots			
Blocks	5	0.032	0.6362
Treatments	1	0.326	0.0017**
Error A	5	0.044	
Split Plots			
Time	3	0.241	0.0001***
Linear	(1)	0.105	0.0014**
Quadratic	(1)	0.029	0.0741
Lack of Fit	(1)	0.107	0.0013**
Treatment X Time	3	0.316	0.0001***
Error B	30	0.255	
Carbon/Nitrogen Ratio Roots			
Whole Plots			
Blocks	5	2.590	0.4673
Treatments	1	13.867	0.0030**
Error A	5	2.398	
Split Plots			
Time	3	1.955	0.3707
Linear	(1)	0.215	0.5545
Quadratic	(1)	0.601	0.3253
Lack of Fit	(1)	1.139	0.1787
Treatment X Time	3	012.030	0.0014**
Error B	30	18.027	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 59. Analyses of variance[z] for spring 1987 data gathered on 'Earliglow' strawberry carbon/nitrogen ratio for crowns, canopy and leaves.

Source	df[y]	SS	Probabilty of F
Carbon/Nitrogen Ratio Crowns			
Whole Plots			
Blocks	5	1.100	0.5357
Treatments	1	10.460	0.0012**
Error A	5	1.197	
Split Plots			
Time	3	13.049	0.0001***
Linear	(1)	0.827	0.0977
Quadratic	(1)	8.394	0.0001***
Lack of Fit	(1)	3.828	0.0009***
Treatment X Time	3	33.190	0.0001***
Error B	30	8.494	
Carbon/Nitrogen Ratio Canopy			
Whole Plots			
Blocks	5	5.009	0.1823
Treatments	1	47.239	0.0001***
Error A	5	2.110	
Split Plots			
Time	3	13.155	0.0001***
Linear	(1)	11.275	0.0001***
Quadratic	(1)	1.223	0.0731
Lack of Fit	(1)	0.656	0.1837
Treatment X Time	3	8.001	0.0007***
Error B	30	10.636	
Carbon/Nitrogen Ratio Leaves			
Whole Plots			
Blocks	5	0.977	0.4548
Treatments	1	32.173	0.0001***
Error A	5	0.878	
Split Plots			
Time	3	18.959	0.0001***
Linear	(1)	16.511	0.0001***
Quadratic	(1)	0.616	0.1206
Lack of Fit	(1)	1.832	0.0099**
Treatment X Time	3	3.616	0.0063**
Error B	30	7.239	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 60. Analyses of variance[z] for spring 1987 data gathered on 'Earliglow' strawberry carbon/nitrogen ratios for petioles, nonfunctional leaves and stolons.

Source	df[y]	SS	Probabilty of F
Carbon/Nitrogen Ratio Petioles			
Whole Plots			
Blocks	5	49.719	0.1444
Treatments	1	142.341	0.0015**
Error A	5	17.989	
Split Plots			
Time	3	38.440	0.0034**
Linear	(0)	Non-estimatible	
Quadratic	(0)	Non-estimatible	
Lack of Fit	(0)	Non-estimatible	
Treatment X Time	3	58.793	0.0003***
Error B	28	62.267	
Carbon/Nitrogen Ratio Nonfunctional Leaves			
Whole Plots			
Blocks	5	0.441	0.5039
Treatments	1	0.115	0.3076
Error A	5	0.445	
Split Plots			
Time	3	4.893	0.0001***
Linear	(0)	Non-estimatible	
Quadratic	(0)	Non-estimatible	
Lack of Fit	(0)	Non-estimatible	
Treatment X Time	3	0.583	0.1113
Error B	28	2.502	
Carbon/Nitrogen Ratio Stolons			
Whole Plots			
Blocks	5	29.139	0.0565
Treatments	1	17.747	0.0153*
Error A	5	2.125	
Split Plots			
Time	3	28.701	0.0312*
Linear	(0)	Non-estimatible	
Quadratic	(0)	Non-estimatible	
Lack of Fit	(0)	Non-estimatible	
Treatment X Time	0	0.000	---
Error B	8	15.423	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 61. Analyses of variance[z] for spring 1987 data gathered on 'Earliglow' strawberry carbon/nitrogen ratios for whole plant.

Source	df[y]	SS	Probabilty of F
Carbon/Nitrogen Ratio Whole Plant			
Whole Plots			
Blocks	5	0.549	0.8091
Treatments	1	19.426	0.0003***
Error A	5	1.263	
Split Plots			
Time	3	23.078	0.0001***
Linear	(1)	9.685	0.0001***
Quadratic	(1)	11.314	0.0001***
Lack of Fit	(1)	2.079	0.0006***
Treatment X Time	3	12.077	0.0001***
Error B	30	4.256	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 62. Analyses of variance[z] for autumn 1987 data gathered on'Earliglow' strawberry for leaves chlorophyll content and for summer 1987 data on crown number, dry mass and individual dry mass.

Source	df[y]	SS	Probabilty of F
Chlorophyll Content			
Whole Plots			
Blocks	5	93.089	0.8686
Treatments	1	292.598	0.0685
Error A	5	272.908	
Split Plots			
Time	9	3002.226	0.0001***
Linear	(0)	Non-estimatible	
Quadratic	(0)	Non-estimatible	
Cubic	(0)	Non-estimatible	
Lack of Fit	(0)	Non-estimatible	
Treatment X Time	9	219.167	0.6586
Error B	89	2873.894	
Crown Number			
Blocks	5	2.634	0.7537
Treatments	1	1.688	0.2526
Error	5	5.048	
Crown Dry Mass			
Blocks	5	1.002	0.8612
Treatments	1	6.163	0.0216*
Error	5	2.840	
Individual Crown Dry Mass			
Blocks	5	0.098	0.7199
Treatments	1	0.781	0.0050**
Error	5	0.171	

[y]Degrees of freedom are reduced by one for each missing observation.

[z]Significance at 0.05=*, 0.01=**, and 0.001=***.

Table 63. Analyses of variance[z] for data gathered on 'Fern' and 'Sparkle' strawberry for autumn 1985 for leaves chlorophyll content and photosynthetic rates based on dry mass, fresh mass, leaf area, and specific leaf weight, and for spring 1986 leaf emergence.

Source	df[y]	SS	Probabilty of F
Chlorophyll Content			
Blocks	7	139.273	0.6912
Treatments	1	8.794	0.5907
Cultivar	1	36.469	0.2786
Treatment X Cultivar	1	173.266	0.0244*
Error	15	619.077	
Photosynthetic Rate Dry Mass			
Blocks	7	14.238	0.4717
Treatments	1	6.888	0.0864
Cultivar	1	5.436	0.1239
Treatment X Cultivar	1	2.211	0.3150
Error	15	30.684	
Photosynthetic Rate Fresh Mass			
Blocks	7	2.177	0.3684
Treatments	1	0.677	0.1294
Cultivar	1	0.511	0.1833
Treatment X Cultivar	1	0.128	0.4955
Error	15	3.942	
Photosynthetic Rate Leaf Area			
Blocks	7	12.290	0.3970
Treatments	1	0.768	0.4933
Cultivar	1	3.572	0.1508
Treatment X Cultivar	1	2.402	0.2334
Error	15	23.367	
Photosynthetic Rate Specific Leaf Weight			
Blocks	7	10.071	0.0981
Treatments	1	0.339	0.4851
Cultivar	1	4.729	0.0174*
Treatment X Cultivar	1	0.429	0.4334
Error	15	9.931	
Leaf Emergence			
Blocks	7	255.879	0.1687
Cultivar&Treatment	3	443.503	0.0022**
Treatments	(1)	12.160	0.4632
Cultivar	(1)	429.966	0.0002**
Treatment X Cultivar	(1)	1.378	0.8038
Error A	21	457.245	
Time	2	686.641	0.0001***
Linear	(1)	684.694	0.0001***
Lack of Fit	(1)	1.947	0.3203
Cultivar&Treatment X Time	6	84.359	0.0001***
Error B	56	108.407	

[y] Degrees of freedom are reduced by one for each missing observation.
[z] Significance at 0.05=*, 0.01=**, 0.001=***.

Table 64. Analyses of variance[z] for dry weights, percent total nonstructural carbohydrates(%TNSC), carbon/nitrogen ratios(C/N) and percent nitrogen(%N) for roots, crowns, canopy and plant on 'Fern'(Fe) and 'Sparkle'(Sp) strawberry, fall 1985(F) and spring 1986(S) Rowcovered=RC and control=NC.

Source	df	Roots SS	Roots Probability of F	Crowns SS	Crowns Probability of F	Canopy SS	Canopy Probability of F	Plant SS	Plant Probability of F
Dry Weight									
Blocks	7	15.308	0.1460	6.093	0.0628	102.327	0.2562	223.383	0.1699
Treatments	7	114.884	0.0001***	23.104	0.0001***	2976.624	0.0001***	4214.390	0.0001***
Fe vs Sp	1	108.646	0.0001***	18.558	0.0001***	944.922	0.0001***	2067.597	0.0001***
FSp vs SSp	1	0.700	0.4719	0.704	0.2001	1475.920	0.0001***	1476.101	0.0001***
FFe vs SFe	1	0.127	0.7591	2.767	0.0131*	448.302	0.0001***	505.382	0.0001***
NCFSp vs RCFSp	1	2.250	0.1998	0.478	0.2896	76.708	0.0110*	119.903	0.0192*
NCSSP vs RCSSP	1	0.014	0.9199	0.506	0.2760	0.946	0.7704	0.021	0.9747
NCFFe vs RCFFe	1	0.967	0.3983	0.080	0.6629	26.953	0.1237	34.712	0.1988
NCSFe vs RCSFe	1	2.181	0.2067	0.009	0.8827	2.873	0.6114	10.677	0.4735
Error	49	65.261		20.451		538.268		1002.547	
Percent Total Nonstructural Carbohydrates									
Blocks	7	70.623	0.3453	32.104	0.3256	84.672	0.0185*	19.358	0.3451
Treatments	7	391.478	0.0001***	259.284	0.0001***	311.100	0.0001***	121.331	0.0001***
Fe vs Sp	1	130.531	0.0003***	1.658	0.5149	173.910	0.0001***	1.868	0.3812
FSp vs SSp	1	1.403	0.6903	105.888	0.0001***	6.845	0.2211	3.888	0.2084
FFe vs SFe	1	102.603	0.0012**	114.421	0.0001***	23.978	0.0246*	24.618	0.0024**
NCFSp vs RCFSp	1	24.751	0.0986	0.601	0.6946	53.656	0.0011**	37.213	0.0003***
NCSSP vs RCSSP	1	95.063	0.0018**	35.135	0.0040**	46.581	0.0022**	51.202	0.0001***
NCFFe vs RCFFe	1	0.526	0.8072	0.856	0.6395	0.490	0.7416	0.827	0.5592
NCSFe vs RCSFe	1	36.603	0.0460*	0.727	0.6659	5.641	0.2661	1.715	0.4013
Error	49	427.838		188.719		218.379		117.243	
Carbon/Nitrogen Ratios									
Blocks	7	9.771	0.8945	71.244	0.0632	29.761	0.0204*	15.693	0.0775
Treatments	7	243.956	0.0001***	171.574	0.0002***	82.926	0.0001***	93.610	0.0001***
Fe vs Sp	1	35.200	0.0024**	48.379	0.0027**	32.285	0.0001***	4.995	0.0410*
FSp vs SSp	1	42.476	0.0010***	30.234	0.0163*	7.53	0.0347*	12.455	0.0017**
FFe vs SFe	1	111.800	0.0001***	47.025	0.0032**	11.684	0.0094**	46.816	0.0001***
NCFSp vs RCFSp	1	1.263	0.5476	0.021	0.9485	6.671	0.0463*	3.595	0.0812
NCSSP vs RCSSP	1	46.080	0.0006***	18.799	0.0555	16.355	0.0024**	22.971	0.0001***
NCFFe vs RCFFe	1	4.262	0.2715	8.436	0.1950	0.103	0.8002	1.684	0.2289
NCSFe vs RCSFe	1	2.375	0.3654	18.132	0.0596	8.293	0.0270*	1.094	0.3308
Error	49	168.797		239.481		78.208		55.574	
Percent Nitrogen									
Blocks	7	0.209	0.5120	1.394	0.0067	0.058	0.8460	0.225	0.1341
Treatments	7	2.161	0.0001***	6.075	0.0001***	3.119	0.0001***	2.554	0.0001***
Fe vs Sp	1	0.003	0.7794	4.439	0.0001***	0.165	0.0033**	0.083	0.0419*
FSp vs SSp	1	0.994	0.0001***	0.483	0.0201*	0.938	0.0001***	1.214	0.0001***
FFe vs SFe	1	0.797	0.0001***	0.312	0.0592	1.638	0.0001***	0.319	0.0001***
NCFSp vs RCFSp	1	0.070	0.1517	0.030	0.5536	0.156	0.0042**	0.123	0.0145*
NCSSP vs RCSSP	1	0.168	0.0238*	0.286	0.0703	0.031	0.1891	0.149	0.0074**
NCFFe vs RCFFe	1	0.045	0.2436	0.172	0.1576	0.0003	0.8946	0.016	0.3689
NCSFe vs RCSFe	1	0.084	0.1175	0.302	0.0631	0.141	0.0063**	0.152	0.0069**
Error	49	1.623		4.097		0.846		0.934	

[z] Degrees of freedom are reduced by one for each missing observation. Significance at 0.05=*, 0.01=** and 0.001=***.

Table 65. Analyses of variance[z] for percent phosphorus(%P), potassium(%K), calcium(%Ca) and magnesium(%Mg) for roots, crowns, canopy and plant on 'Fern'(Fe) and 'Sparkle'(Sp) strawberry, fall 1985(F) and spring 1986(S). Rowcovered=RC and Control=NC.

Source	df	Roots SS	Roots Probability of F	Crowns SS	Crowns Probability of F	Canopy SS	Canopy Probability of F	Plant SS	Plant Probability of F
Percent Phosphorus									
Blocks	7	0.004	0.3863	0.006	0.0787	0.014	0.1249	0.591	0.1165
Treatments	7	0.049	0.0001***	0.195	0.0001***	0.191	0.0001***	9.536	0.0001***
Fe vs Sp	1	0.005	0.0019**	0.022	0.0001***	0.002	0.2440	0.192	0.0505
FSp vs SSp	1	0.018	0.0001***	0.099	0.0001***	0.107	0.0001***	5.970	0.0001***
FFe vs SFe	1	0.023	0.0001***	0.070	0.0001***	0.068	0.0001***	2.870	0.0001***
NCFSp vs RCFSp	1	0.0001	0.7139	0.001	0.2636	0.001	0.4103	0.030	0.4328
NCSSp vs RCSSp	1	0.002	0.0564	0.0002	0.5178	0.005	0.0457*	0.224	0.0353*
NCFFe vs RCFFe	1	0.0000	0.9945	0.001	0.1306	0.002	0.2348	0.070	0.2328
NCSFe vs RCSFe	1	0.001	0.1888	0.002	0.0336*	0.006	0.0327*	0.179	0.0588
Error	49	0.023		0.021		0.058		2.346	
Percent Potassium									
Blocks	7	0.042	0.8276	0.052	0.5962	0.271	0.3393	6.910	0.6061
Treatments	7	0.785	0.0001***	1.429	0.0001***	1.987	0.0001***	16.916	0.0876
Fe vs Sp	1	0.050	0.0469*	0.581	0.0001***	0.011	0.5619	2.649	0.1540
FSp vs SSp	1	0.111	0.0038**	0.138	0.0003***	0.891	0.0001***	0.949	0.3903
FFe vs SFe	1	0.556	0.0001***	0.647	0.0001***	0.900	0.0001***	0.895	0.4041
NCFSp vs RCFSp	1	0.002	0.7023	0.011	0.2817	0.057	0.1947	4.394	0.0682
NCSSP vs RCSSP	1	0.003	0.7023	0.002	0.6265	0.109	0.0755	1.828	0.2349
NCFFe vs RCFFe	1	0.058	0.033*	0.032	0.0648	0.010	0.5944	5.296	0.0460*
NCSFe vs RCSFe	1	0.005	0.5187	0.018	0.1579	0.009	0.6109	0.904	0.4017
Error	49	0.588		0.436		1.626		61.913	
Percent Calcium									
Blocks	7	0.075	0.0003***	0.105	0.0074**	0.029	0.7482	7.743	0.0020**
Treatments	7	0.416	0.0001***	1.031	0.0001***	1.398	0.0001***	25.086	0.0001***
Fe vs Sp	1	0.008	0.0652	0.278	0.0001***	0.414	0.0001***	15.318	0.0001***
FSp vs SSp	1	0.143	0.0001***	0.452	0.0001***	0.339	0.0001***	5.950	0.0001***
FFe vs SFe	1	0.264	0.0001***	0.300	0.0001***	0.576	0.0001***	0.797	0.1018
NCFSp vs RCFSp	1	0.0002	0.7715	0.0002	0.8488	0.049	0.0103*	2.438	0.0053**
NCSSP vs RCSSP	1	0.001	0.5492	0.001	0.5836	0.011	0.2192	0.058	0.6561
NCFFe vs RCFFe	1	0.00002	0.9317	0.0004	0.7831	0.006	0.3580	0.523	0.1833
NCSFe vs RCSFe	1	0.001	0.5408	0.0001	0.9135	0.002	0.5540	0.002	0.9397
Error	49	0.108		0.231		0.340		14.059	
Percent Magnesium									
Blocks	7	0.007	0.1143	0.006	0.0363*	0.008	0.2634	0.516	0.0252
Treatments	7	0.110	0.0001***	0.129	0.0001***	0.066	0.0001***	3.386	0.0001
Fe vs Sp	1	0.006	0.0019**	0.024	0.0001***	0.053	0.0001***	0.885	0.0001
FSp vs SSp	1	0.028	0.0001***	0.049	0.0001***	0.002	0.1456	0.131	0.0373
FFe vs SFe	1	0.073	0.0001***	0.056	0.0001***	0.005	0.0184*	1.934	0.0001
NCFSp vs RCFSp	1	0.0000	0.9485	0.0002	0.4942	0.005	0.0139*	0.291	0.0026
NCSSP vs RCSSP	1	0.002	0.0546	0.00001	0.3545	0.00000	0.9533	0.041	0.2393
NCFFe vs RCFFe	1	0.001	0.2254	0.0001	0.5941	0.0002	0.6361	0.055	0.1728
NCSFe vs RCSFe	1	0.001	0.2735	0.00000	0.9371	0.0001	0.7580	0.048	0.2014
Error	49	0.143		0.154		0.041		1.413	

[z] Degrees of freedom are reduced by one for each missing observation. Significance at 0.05=*, 0.01=** and 0.001=***.

Table 66. Analyses of variance[z] for parts per million manganese(ppmMn), iron(ppmFe), copper(ppmCu), and boron(ppmB) for roots, crowns, canopy and plant on 'Fern'(Fe) and 'Sparkle'(Sp) strawberry, fall 1985(F) and spring 1986(S). Rowcovered=RC and Control=NC.

Source	df	Roots SS	Roots Probability of F	Crowns SS	Crowns Probability of F	Canopy SS	Canopy Probability of F	Plant SS	Plant Probability of F
Parts Per Million Manganese									
Blocks	7	5437.281	0.0126*	27415.455	0.0014**	115251.247	0.0009***	46335.273	0.0036**
Treatments	7	49707.226	0.0001***	55743.819	0.0001***	94431.300	0.0040**	38637.892	0.0113*
Fe vs Sp	1	323.955	0.2761	10216.408	0.0021**	68266.585	0.0001***	28612.886	0.0003***
FSp vs SSp	1	18495.895	0.0001***	19283.043	0.0001***	12318.613	0.0798	5327.133	0.0970
FFe vs SFe	1	29354.645	0.0001***	23127.552	0.0001***	7576.190	0.1669	405.845	0.6426
NCFSp vs RCFSp	1	32.49	0.7287	729.405	0.3895	4374.169	0.2916	3646.112	0.1679
NCSSP vs RCSSP	1	2.364	0.9254	2172.026	0.1405	567.869	0.7025	529.789	0.5961
NCFFe vs RCFFe	1	18.707	0.7924	38.162	0.8434	0.0004	0.9997	100.650	0.8171
NCSFe vs RCSFe	1	1479.172	0.0226*	177.223	0.6705	1327.874	0.5596	15.477	0.9277
Error	49	13083.209		47410.809		188562.730		91198.296	
Parts Per Million Iron									
Blocks	7	883191.218	0.1143	236249.729	0.1044	316992.335	0.5670	315970.313	0.2356
Treatments	7	16812560.750	0.0001***	2842480.057	0.0001***	1202379.335	0.0079**	8189221.400	0.0001***
Fe vs Sp	1	731965.803	0.0024**	18231.751	0.3262	14880.950	0.6037	217083.553	0.0131*
FSp vs SSp	1	6406589.101	0.0001***	1494461.161	0.0001***	836247.781	0.0003***	3548088.500	0.0001***
FFe vs SFe	1	8984348.551	0.0001***	1246620.500	0.0001***	72818.820	0.2534	4172597.534	0.0001***
NCFSp vs RCFSp	1	466.560	0.9358	8667.610	0.4973	7310.250	0.7158	2544.584	0.7816
NCSSP vs RCSSP	1	2185.563	0.8616	6312.303	0.5622	162852.603	0.0902	14436.252	0.5098
NCFFe vs RCFFe	1	592.923	0.9277	3492.810	0.6661	95836.681	0.1910	38646.750	0.2826
NCSFe vs RCSFe	1	686412.250	0.0032**	64693.923	0.0677	12432.250	0.6351	195824.226	0.0181*
Error	49	3488017.783		908336.378		2671055.934		1604438.170	
Parts Per Million Copper									
Blocks	7	957.868	0.5241	489.331	0.0499*	27.982	0.0173*	141.830	0.7116
Treatments	7	2039.787	0.0918	1182.910	0.0001***	206.243	0.0001***	1332.708	0.0001***
Fe vs Sp	1	192.936	0.2690	399.200	0.0009***	29.587	0.0001***	22.240	0.4020
FSp vs SSp	1	200.390	0.2600	304.675	0.0032**	103.612	0.0001***	346.036	0.0016**
FFe vs SFe	1	1280.851	0.0059**	317.520	0.0027**	68.398	0.0001***	834.903	0.0001***
NCFSp vs RCFSp	1	0.002	0.9972	26.626	0.3640	0.150	0.7495	0.224	0.9327
NCSSP vs RCSSP	1	1.522	0.9213	60.218	0.1745	0.171	0.7329	8.388	0.6060
NCFFe vs RCFFe	1	0.136	0.9764	63.163	0.1645	0.030	0.8865	0.351	0.9158
NCSFe vs RCSFe	1	363.951	0.1311	11.510	0.5467	4.300	0.0921	120.565	0.0547
Error	49	7562.417		1554.200		71.285		1524.679	
Parts Per Million Boron									
Blocks	7	27.446	0.0627	24.757	0.0685	192.375	0.0690	83.873	0.1214
Treatments	7	17.360	0.2612	112.300	0.0001***	893.669	0.0001***	843.965	0.0001***
Fe vs Sp	1	0.668	0.5537	3.312	0.1713	204.669	0.0003***	159.748	0.0001***
FSp vs SSp	1	7.450	0.0521	41.564	0.0001***	391.440	0.0001***	495.757	0.0001***
FFe vs SFe	1	3.290	0.1920	62.412	0.0001***	95.462	0.0105*	161.533	0.0001***
NCFSp vs RCFSp	1	0.833	0.5093	1.015	0.4447	32.747	0.1257	8.354	0.2760
NCSSP vs RCSSP	1	1.056	0.4571	0.990	0.4534	23.741	0.1908	4.922	0.4019
NCFFe vs RCFFe	1	0.797	0.5181	0.226	0.7198	29.783	0.1505	1.793	0.6121
NCSFe vs RCSFe	1	3.267	0.1935	2.731	0.2113	121.326	0.0042**	11.956	0.1955
Error	49	92.084		84.917		661.087		337.284	

[z] Degrees of freedom are reduced by one for each missing observation. Significance at 0.05=*, 0.01=** and 0.001=***.

Table 67. Analyses of variance[z] on for parts per million zinc(ppmZn) for roots, crowns, canopy and plant on 'Fern' (Fe) and 'Sparkle'(Sp) strawberry, fall 1985(F) and spring 1986(S). Rowcovered=RC and Control=NC.

Source	df	Roots SS	Roots Probability of F	Crowns SS	Crowns Probability of F	Canopy SS	Canopy Probability of F	Plant SS	Plant Probability of F
Parts Per Million Zinc									
Blocks	7	998.188	0.0195*	6702.823	0.0933	2055.027	0.5326	1539.691	0.2655
Treatments	7	4110.783	0.0001***	49498.543	0.0001***	4456.549	0.1174	14318.646	0.0001***
Fe vs Sp	1	1.806	0.8544	35213.930	0.0001***	1026.561	0.0986	478.425	0.0977
FSp vs SSp	1	1023.329	0.0001***	5822.554	0.0016**	949.281	0.1118	6217.753	0.0001***
FFe vs SFe	1	2709.032	0.0001***	3496.988	0.0124*	31.541	0.7691	5754.268	0.0001***
NCFSp vs RCFSp	1	0.879	0.8981	548.145	0.3089	31.725	0.7685	16.373	0.7561
NCSSP vs RCSSP	1	227.784	0.0436	4382.440	0.0055**	2365.850	0.0137*	1751.111	0.0022**
NCFFe vs RCFFe	1	0.270	0.9434	15.563	0.8632	51.517	0.7076	99.864	0.4442
NCSFe vs RCSFe	1	147.683	0.1017	18.923	0.8493	0.073	0.9887	0.853	0.9435
Error	49	2601.059		25403.242		17741.239		8225.290	

[z] Degrees of freedom are reduced by one for each missing observation. Significance at 0.05=*, 0.01=** and 0.001=***.

Table 68. Analyses of variance[z] for dry weights of roots, crowns, canopy, leaves, petioles, nonfunctional leaves, stolons, flowers, plant, individual crowns and indivdual stolons on 'Earliglow' strawberry, spring 1987.

Source	df	First Sampling SS	First Sampling Probability of F	Second Sampling SS	Second Sampling Probability of F	Third Sampling SS	Third Sampling Probability of F	Fourth Sampling SS	Fourth Sampling Probability of F
Root Dry Weight									
Blocks	5	18.309	0.4469	14.782	0.7225	28.638	0.5026	16.470	0.2886
Treatments	1	0.029	0.9286	2.199	0.5429	4.609	0.4121	0.00001	0.9979
Error	5	16.151		25.829		28.813		9.726	
Crown Dry Weight									
Blocks	5	5.460	0.5532	1.700	0.9670	6.100	0.3950	2.810	0.1531
Treatments	1	0.219	0.6918	0.108	0.8306	4.742	0.0757	4.663	0.0053**
Error	5	6.193		10.597		4.748		1.055	
Canopy Dry Weight									
Blocks	5	19.387	0.3837	5.125	0.7936	13.476	0.6796	15.274	0.3267
Treatments	1	12.690	0.0921	11.993	0.0683	123.778	0.0029**	155.376	0.0003***
Error	5	14.676		11.167		20.931		9.999	
Leaf Dry Weight									
Blocks	5	10.077	0.4498	3.978	0.7105	7.651	0.6700	7.512	0.2666
Treatments	1	5.423	0.1423	7.239	0.0680	66.819	0.0030**	66.537	0.0003***
Error	5	8.950		6.721		11.586		4.165	
Petiole Dry Weight									
Blocks	5	1.559	0.2278	0.168	0.9252	0.939	0.6706	1.867	0.4397
Treatments	1	1.522	0.0254*	0.597	0.0907	8.710	0.0027**	18.559	0.0006***
Error	5	0.768		0.682		1.425		1.619	
Nonfunctional Leaves Dry Weight									
Blocks	5	72.301	0.7456	34.964	0.7247	33.162	0.8940	5.058	0.4654
Treatments	1	43.956	0.2583	22.177	0.2370	89.489	0.1006	2.344	0.1737
Error	5	135.167		61.481		110.676		4.662	
Stolon Dry Weight									
Blocks	5	1.125	0.3571	1.080	0.6642	0.675	0.5377	0.309	0.4216
Treatments	1	1.090	0.0474*	1.920	0.0585	0.755	0.0731	0.169	0.1295
Error	5	0.797		1.610		0.738		0.257	
Flower Dry Weight									
Blocks	5	--	--	--	--	0.021	0.5000	0.907	0.4898
Treatments	1	--	--	--	--	0.252	0.0006***	3.081	0.0087**
Error	5	--		--		0.021		0.885	
Plant Dry Weight									
Blocks	5	276.179	0.4720	132.016	0.6723	235.976	0.0314*	105.568	0.1509
Treatments	1	5.391	0.7598	1.675	0.8464	690.690	0.7059	335.809	0.0013**
Error	5	258.509		201.133		393.617		39.274	
Individual Crown Dry Weight									
Blocks	5	0.258	0.4604	0.150	0.7236	0.651	0.2304	0.148	0.3782
Treatments	1	0.001	0.8758	0.003	0.8163	0.009	0.7261	0.713	0.0023**
Error	5	0.235		0.262		0.323		0.110	
Individual Stolon Dry Weight									
Blocks	5	0.015	0.3976	0.968	0.6186	0.186	0.8846	0.558	0.5534
Treatments	1	0.107	0.0229*	0.319	0.3359	0.0002	0.9690	0.034	0.6284
Error	5	0.051		(3)0.733		(2)0.255		(2)0.212	

[z] Degrees of freedom are reduced by one for each missing observation. Significance at 0.05=*, 0.01=** and 0.001=***.

Table 69. Analyses of variance[z] for number of crowns, leaves, nonfunctional leaves, runners, flowers, trusses, leaves per crown, nonfunctional leaves per crown, dead flowers, and total leaf area and mean leaf areaon 'Earliglow' strawberry, spring 1987.

Source	df	First Sampling SS	First Sampling Probability of F	Second Sampling SS	Second Sampling Probability of F	Third Sampling SS	Third Sampling Probability of F	Fourth Sampling SS	Fourth Sampling Probability of F
Crown Number									
Blocks	5	1.935	0.9509	1.519	0.9328	2.602	0.7920	1.046	0.5000
Treatments	1	0.083	0.8452	0.000	1.0000	2.083	0.2322	3.343	0.0104*
Error	5	9.861		6.556		5.639		1.046	
Leaf Number									
Blocks	5	12.185	0.4379	21.157	0.7545	21.750	0.8844	74.333	0.5172
Treatments	1	0.926	0.5364	18.750	0.1893	246.009	0.0083**	9.481	0.4693
Error	5	10.519		40.639		68.935		77.407	
Nonfunctional Leaf Number									
Blocks	5	27.861	0.9310	31.222	0.8325	30.972	0.7946	9.046	0.3131
Treatments	1	18.750	0.4145	37.926	0.1806	32.231	0.1835	1.120	0.3675
Error	5	118.528		78.407		67.713		5.713	
Runner Number									
Blocks	5	9.111	0.3678	0.972	0.9811	0.852	0.5519	1.519	0.3701
Treatments	1	0.037	0.8738	2.676	0.2508	3.704	0.0071**	1.333	0.0580
Error	5	6.30		7.935		0.963		1.111	
Flower Number									
Blocks	5	--	--	--	--	15.296	0.5000	96.380	0.6097
Treatments	1	--	--	--	--	855.704	0.0001***	49.343	0.2195
Error	5	--		--		15.296		125.269	
Truss Number									
Blocks	5	--	--	--	--	0.528	0.5000	1.667	0.6748
Treatments	1	--	--	--	--	14.083	0.0001***	0.333	0.4560
Error	5	--		--		0.528		2.556	
Leaves per Crown									
Blocks	5	0.432	0.7883	1.417	0.5965	3.415	0.7742	3.585	0.2696
Treatments	1	0.114	0.4688	2.191	0.0560	15.293	0.0212**	5.250	0.0153*
Error	5	0.925		1.784		6.977		2.005	
Nonfunctional Leaves per Crown									
Blocks	5	2.300	0.4550	2.372	0.8050	3.996	0.6156	0.467	0.3650
Treatments	1	0.396	0.3727	3.935	0.1139	0.509	0.5179	0.158	0.1863
Error	5	2.067		5.376		5.269		0.337	
Dead Flower Number									
Blocks	5	--	--	--	--	--	--	16.407	0.5855
Treatments	1	--	--	--	--	--	--	176.333	0.0021**
Error	5	--		--		--		25.889	
Total Leaf Area									
Blocks	5	271024.763	0.4431	43704.230	0.8625	137095.708	0.5710	156458.135	0.4112
Treatments	1	208163.032	0.0902	75247.210	0.1427	1124931.691	0.0020**	738002.969	[illegible]029**
Error	5	236875.329		124578.591		162220.927		126660.285	
Mean Leaf Area									
Blocks	5	2010.330	0.3877	246.350	0.9431	300.389	0.2818	450.440	0.7079
Treatments	1	3746.859	0.0174*	117.546	0.5089	1924.887	0.0007***	1705.054	0.0201*
Error	5	1536.887		1162.958		173.983		755.528	

[z] Degrees of freedom are reduced by one for each missing observation. Significance at 0.05=*, 0.01=** and 0.001=***.

Table 70. Analyses of variance[z] for percent fructose, glucose, sucrose, maltose and starch in leaves; fructose, glucose, sucrose, maltose and starch percent of total nonstructural carbohydrates(TNSC) in leaf blades and specific leaf weight of 'Earliglow' strawberry, spring 1987.

Source	df	First Sampling SS	First Sampling Probability of F	Second Sampling SS	Second Sampling Probability of F	Third Sampling SS	Third Sampling Probability of F	Fourth Sampling SS	Fourth Sampling Probability of F
<u>Percent Fructose</u>									
Blocks	5	0.292	0.5164	0.425	0.3583	0.502	0.3096	0.187	0.1107
Treatments	1	0.011	0.6905	1.656	0.0034**	0.804	0.0159*	0.020	0.2403
Error	5	0.303		0.302		0.314		0.058	
<u>Percent Glucose</u>									
Blocks	5	0.230	0.6023	0.329	0.3270	0.286	0.3720	0.224	0.0673
Treatments	1	0.014	0.6496	1.163	0.0035**	0.781	0.0076**	0.082	0.0379*
Error	5	0.293		0.216		0.210		0.052	
<u>Percent Sucrose</u>									
Blocks	5	0.320	0.9295	0.115	0.8689	0.884	0.1746	0.577	0.5599
Treatments	1	0.156	0.4804	3.713	0.0007***	0.015	0.6654	0.049	0.5686
Error	5	1.345		0.337		0.362		0.665	
<u>Percent Maltose</u>									
Blocks	5	0.024	0.2673	0.030	0.8266	0.070	0.5000	0.016	0.4232
Treatments	1	0.003	0.3632	0.000	1.0000	0.003	0.6793	0.011	0.1019
Error	5	0.014	0.073	0.073		0.070		0.014	
<u>Percent Starch</u>									
Blocks	5	2.830	0.7550	3.102	0.9089	3.148	0.4686	7.345	0.8331
Treatments	1	8.385	0.0392*	10.011	0.0892	25.503	0.0012**	30.861	0.0342*
Error	5	5.443		11.300		2.924		18.491	
<u>Fructose Percent of TNSC</u>									
Blocks	5	70.215	0.7341	49.266	0.8753	35.031	0.4457	21.778	0.3031
Treatments	1	50.253	0.2184	9.743	0.5924	4.896	0.4157	6.406	0.1826
Error	5	126.888		149.185		30.809		13.385	
<u>Glucose Percent of TNSC</u>									
Blocks	5	52.816	0.7907	37.011	0.8412	19.184	0.5524	23.588	0.1299
Treatments	1	34.300	0.2745	9.924	0.5049	9.778	0.1938	0.423	0.6289
Error	5	113.951		96.259		21.716		7.988	
<u>Sucrose Percent of TNSC</u>									
Blocks	5	85.133	0.9325	37.917	0.5522	98.503	0.1642	42.430	0.6768
Treatments	1	12.858	0.6928	266.660	0.0026**	8.109	0.3531	13.791	0.3516
Error	5	366.577		42.892		38.713		65.402	
<u>Maltose Percent of TNSC</u>									
Blocks	5	6.519	0.3541	8.957	0.8529	14.163	0.4678	1.232	0.4457
Treatments	1	0.142	0.7097	8.794	0.2377	4.488	0.2479	0.483	0.1955
Error	5	4.582		24.4667		13.126		1.083	
<u>Starch Percent of TNSC</u>									
Blocks	5	345.079	0.6019	204.199	0.8869	189.008	0.4433	113.675	0.6603
Treatments	1	94.810	0.3468	385.567	0.1471	0.139	0.9507	38.434	0.3335
Error	5	440.001		655.873		165.307		167.840	
<u>Specific Leaf Weight</u>									
Blocks	5	0.000001	0.9917	0.00001	0.8147	0.000005	0.7397	0.000001	0.7179
Treatments	1	0.000002	0.1559	0.00001	0.3087	0.00001	0.0726	0.00002	0.0022**
Error	5	0.000003		0.00002		0.00001		0.000002	

[z] Degrees of freedom are reduced by one for each missing observation. Significance at 0.05=*, 0.01=** and 0.001=***.

Table 71. Analyses of variance[z] for percent total nonstructural carbohydrates(%TNSC) for roots, crowns, canopy, leaves, petioles, nonfunctional leaves, stolons, flowers, and plant, and percent nitrogen(%N) for roots and crowns on 'Earliglow' strawberry, spring 1987.

Source	df	First Sampling SS	First Sampling Probability of F	Second Sampling SS	Second Sampling Probability of F	Third Sampling SS	Third Sampling Probability of F	Fourth Sampling SS	Fourth Sampling Probability of F
Percent Total Nonstructural Carbohydrates Roots									
Blocks	5	19.658	0.0224*	7.453	0.3556	18.467	0.5313	5.606	0.3757
Treatments	1	1.021	0.2207	0.068	0.8101	8.789	0.1973	39.205	0.0010***
Error	5	2.607		5.257		19.890		4.160	
Percent Total Nonstructural Carbohydrates Crowns									
Blocks	5	4.136	0.2262	5.039	0.1582	3.769	0.6312	5.446	0.5886
Treatments	1	5.590	0.0138*	21.333	0.0007***	34.003	0.0023**	26.314	0.0069**
Error	5	2.027		1.933		5.168		6.723	
Percent Total Nonstructural Carbohydrates Canopy									
Blocks	5	2.453	0.8476	6.824	0.6933	7.477	0.2623	5.934	0.7559
Treatments	1	8.700	0.0496*	48.020	0.0055**	46.693	0.0006***	39.235	0.0090**
Error	5	6.551		10.996		4.094		11.446	
Percent Total Nonstructural Carbohydrates Leaves									
Blocks	5	1.495	0.8684	4.472	0.7593	5.983	0.4871	5.934	0.3185
Treatments	1	12.690	0.0125*	55.599	0.0024**	47.641	0.0014**	34.409	0.0175*
Error	5	4.378		8.717		5.803		14.129	
Percent Total Nonstructural Carbohydrates Petioles									
Blocks	5	14.853	0.6933	41.217	0.5118	38.141	0.0580	16.416	0.2977
Treatments	1	0.015	0.9580	30.624	0.1158	50.882	0.0025**	62.929	0.0025**
Error	5	23.934		42.383		8.164		9.939	
Percent Total Nonstructural Carbohydrates Nonfunctional Leaves									
Blocks	5	2.150	0.1123	1.681	0.5067	0.451	0.8731	1.299	0.5000
Treatments	1	0.584	0.0906	0.039	0.7488	0.0004	0.9717	1.294	0.0760
Error	5	0.667		1.708		1.349		1.299	
Percent Total Nonstructural Carbohydrates Stolons									
Blocks	5	8.533	0.2647	29.595	0.8402	6.610	0.5000	39.004	0.5000
Treatments	1	16.404	0.0087**	18.625	0.3206	5.576	0.0952	28.305	0.1151
Error	5	4.706		76.671		6.610		39.004	
Percent Total Nonstructural Carbohydrates Flowers									
Blocks	5	--	--	--	--	3.916	0.5000	77.0644	0.0219*
Treatments	1	--	--	--	--	336.021	0.0001***	19.789	0.0260*
Error	5	--		--		3.916		10.119	
Percent Total Nonstructural Carbohydrates Plant									
Blocks	5	1.897	0.1949	1.929	0.4057	2.139	0.9285	1.785	0.3456
Treatments	1	0.770	0.0848	2.362	0.0394*	18.014	0.0246*	52.013	0.0007***
Error	5	0.837		1.541		8.922		4.726	
Percent Nitrogen Roots									
Blocks	5	0.143	0.1799	0.202	0.0748	0.057	0.9737	0.085	0.7799
Treatments	1	0.031	0.1678	0.057	0.0613	0.132	0.2548	0.323	0.0296*
Error	5	0.060		0.050		0.400		0.178	
Percent Nitrogen Crowns									
Blocks	5	0.017	0.3936	0.039	0.3252	0.013	0.9935	0.035	0.7882
Treatments	1	0.020	0.0399*	0.147	0.0031**	0.546	0.0100**	0.411	0.0034**
Error	5	0.013		0.026		0.168		0.075	

[z] Degrees of freedom are reduced by one for each missing observation. Significance at 0.05=*, 0.01=** and 0.001=***.

Table 72. Analyses of variance[z] for percent nitrogen(%N) for canopy, leaves, petioles, nonfunctional leaves, stolons, flowers and plant, and carbon/nitrogen (C/N) ratios for roots, crowns, canopy and leaves on 'Earliglow' strawberry, spring 1987.

Source	df	First Sampling SS	First Sampling Probability of F	Second Sampling SS	Second Sampling Probability of F	Third Sampling SS	Third Sampling Probability of F	Fourth Sampling SS	Fourth Sampling Probability of F
Percent Nitrogen Canopy									
Blocks	5	0.034	0.7071	0.571	0.1651	1.106	0.4061	0.263	0.2386
Treatments	1	0.055	0.0780	0.003	0.8095	0.202	0.3336	3.181	0.0001***
Error	5	0.057		0.225		0.884		0.134	
Percent Nitrogen Leaves									
Blocks	5	0.018	0.8552	0.503	0.3412	0.426	0.8861	0.421	0.1604
Treatments	1	0.026	0.1692	0.006	0.7776	0.059	0.6618	3.575	0.0001***
Error	5	0.051		0.342		1.363		0.163	
Percent Nitrogen Petioles									
Blocks	5	0.032	0.9215	0.327	0.7165	0.217	0.6167	0.064	0.5795
Treatments	1	0.004	0.6928	0.599	0.0692	1.748	0.0109*	1.281	0.0003***
Error	5	0.126		0.562		(3)0.164		0.078	
Percent Nitrogen Nonfunctional Leaves									
Blocks	5	0.068	0.2052	0.129	0.4501	0.117	0.6286	0.613	0.0195*
Treatments	1	0.053	0.0326*	0.048	0.2067	0.006	0.6913	0.724	0.0200*
Error	5	0.031		0.115		0.159		0.056	
Percent Nitrogen Stolons									
Blocks	5	(1)0.002	--	0.172	0.3560	0.276	--	(2)0.097	--
Treatments	1	(0)0.000	--	0.001	0.8737	0.018	--	0.451	--
Error	5	(0)0.000		(3)0.061		(0)0.000		(0)0.000	
Percent Nitrogen Flowers									
Blocks	5	--	--	--	--	(3)0.095	--	0.088	0.8665
Treatments	1	--	--	--	--	(0)0.000	--	2.134	0.0030**
Error	5	--		--		(0)0.000		(4)0.207	
Percent Nitrogen Plant									
Blocks	5	0.006	0.8566	0.019	0.8343	0.029	0.9475	0.024	0.7380
Treatments	1	0.014	0.1021	0.224	0.1838	0.011	0.5700	0.595	0.0004***
Error	5	0.0176		0.047		0.142		0.046	
Carbon/Nitrogen Ratios Roots									
Blocks	5	5.351	0.0340*	1.100	0.6686	5.127	0.5096	2.169	0.3468
Treatments	1	0.026	0.7162	0.264	0.4129	4.977	0.0813	20.630	0.0004***
Error	5	0.871		1.659		5.244		1.496	
Carbon/Nitrogen Ratios Crowns									
Blocks	5	0.889	0.1033	1.232	0.1655	0.938	0.7078	2.435	0.5845
Treatments	1	0.710	0.0143*	2.715	0.0032**	18.145	0.0006***	22.080	0.0017**
Error	5	0.262		0.487		1.573		2.976	
Carbon/Nitrogen Ratios Canopy									
Blocks	5	0.824	0.7695	2.916	0.4052	1.495	0.6676	1.765	0.5522
Treatments	1	3.195	0.0268*	7.670	0.0097**	11.178	0.0042**	30.064	0.0003***
Error	5	1.659		2.327		2.249		1.997	
Carbon/Nitrogen Ratios Leaves									
Blocks	5	0.367	0.9283	0.896	0.6644	0.192	0.9897	0.421	0.1604
Treatments	1	2.899	0.0103*	6.686	0.0041**	7.388	0.0084**	3.575	0.0001***
Error	5	0.906		1.338		2.081		0.1630	

[z] Degrees of freedom are reduced by one for each missing observation. Significance at 0.05=*, 0.01=** and 0.001=***.

Table 73. Analyses of variance[z] for carbon/nitrogen (C/N) ratios for petioles, nonfunctional leaves, stolons, flowers and plant on 'Earliglow' strawberry, spring 1987.

Source	df	First Sampling SS	First Sampling Probability of F	Second Sampling SS	Second Sampling Probability of F	Third Sampling SS	Third Sampling Probability of F	Fourth Sampling SS	Fourth Sampling Probability of F
<u>Carbon/Nitrogen Ratios Petioles</u>									
Blocks	5	14.038	0.6229	22.376	0.5410	26.015	0.0662	10.658	0.4609
Treatments	1	0.215	0.8209	29.478	0.0583	46.081	0.0040**	121.767	0.0005***
Error	5	18.852		24.648		(3)2.137		9.720	
<u>Carbon/Nitrogen Ratios Nonfunctional Leaves</u>									
Blocks	5	0.730	0.1647	0.545	0.4697	0.128	0.8681	(4)0.408	0.5000
Treatments	1	0.941	0.2569	0.026	0.6340	0.001	0.8957	0.568	0.0777
Error	5	0.288		0.507		0.374		0.408	
<u>Carbon/Nitrogen Ratios Stolons</u>									
Blocks	5	(1)0.324	--	31.458	0.0582	4.079	--	(2)8.606	--
Treatments	1	(0)0.000	--	0.161	0.6806	1.261	--	(1)13.477	--
Error	5	(0)0.000		(3)2.344		(0)0.000		(0)0.000	
<u>Carbon/Nitrogen Ratios Flowers</u>									
Blocks	5	--	--	--	--	(3)0.474	--	7.829	0.4688
Treatments	1	--	--	--	--	(0)0.000	--	19.428	0.0038**
Error	5	--		--		(0)0.000		(4)2.142	
<u>Carbon/Nitrogen Ratios Plant</u>									
Blocks	5	0.516	0.3184	0.441	0.5418	0.267	0.9779	0.596	0.8163
Treatments	1	0.376	0.0629	0.812	0.0343*	5.084	0.0165*	25.052	0.0002***
Error	5	0.331		0.487		2.024		1.407	

[z] Degrees of freedom are reduced by one for each missing observation. Significance at 0.05=*, 0.01=** and 0.001=***.

Table 74. Analyses of varience[z] for dry weights for roots, crowns, canopy, leaves, petioles, stolons, plant, individual crownsand individual stolons, specific leaf weight and leaves per crown on 'Earliglow' strawberry, autumn 1986.

Source	df	First Sampling SS	First Sampling Probability of F	Second Sampling SS	Second Sampling Probability of F	Third Sampling SS	Third Sampling Probability of F	Fourth Sampling SS	Fourth Sampling Probability of F	Fifth Sampling SS	Fifth Sampling Probability of F
Root Dry Weight											
Blocks	5	1.089	0.3239	17.183	0.2832	44.917	0.8567	60.083	0.0086**	27.770	0.1984
Treatments	1	0.194	0.2942	3.682	0.2327	0.773	0.8671	0.002	0.9694	0.152	0.8144
Error	5	0.708		9.992		124.745		5.015		12.397	
Crown Dry Weight											
Blocks	5	1.230	0.6082	1.550	0.1486	1.311	0.8826	6.843	0.0781	2.439	0.0097**
Treatments	1	0.00001	0.9961	1.042	0.0294*	0.002	0.9670	0.122	0.5776	0.028	0.4583
Error	5	1.592		0.571		4.116		1.722		0.220	
Canopy Dry Weight											
Blocks	5	37.765	0.8561	61.307	0.6107	269.560	0.1128	289.516	0.0266*	28.983	0.2032
Treatments	1	21.646	0.3558	48.642	0.1415	53.074	0.1353	11.603	0.2916	32.791	0.0167*
Error	5	104.631		79.882		83.826		41.54		13.158	
Leaves Dry Weight											
Blocks	5	19.244	0.8636	23.039	0.7261	123.686	0.1234	140.201	0.0297*	13.661	0.1572
Treatments	1	10.047	0.3837	27.040	0.1279	18.617	0.1903	2.884	0.4483	20.602	0.0067**
Error	5	55.140		40.683		40.583		21.322		5.218	
Petiole Dry Weight											
Blocks	5	3.096	0.8554	9.348	0.3894	28.137	0.1231	27.959	0.0237*	3.297	0.2894
Treatments	1	2.199	0.3083	3.148	0.1986	8.824	0.0804	2.917	0.1078	1.410	0.1157
Error	5	8.552		7.176		9.222		3.812		19.51	
Stolon Dry Weight											
Blocks	5	--	--	--	--	3.482	0.1216	3.318	0.2295	3.939	0.4272
Treatments	1	--	--	--	--	0.506	0.1954	0.922	0.1547	4.284	0.0517
Error	5	--		--		1.133		1.643		3.314	
Plant Dry Weight											
Blocks	5	66.201	0.7939	132.510	0.5228	375.806	0.5803	811.724	0.0122*	88.587	0.0651
Treatments	1	25.970	0.3865	98.289	0.1197	78.081	0.3967	15.816	0.3685	57.378	0.0130*
Error	5	144.402		139.812		454.735		80.992		20.172	
Individual Crown Dry Weight											
Blocks	5	0.387	0.0255	0.464	0.7953	0.581	0.2827	1.191	0.5712	0.493	0.1760
Treatments	1	0.051	0.0826	0.076	0.5682	0.417	0.0554	0.114	0.5527	0.011	0.6109
Error	5	0.055		1.017		0.337		1.410		0.203	
Individual Stolon Dry Weight											
Blocks	5	--	--	--	--	0.402	0.0361	0.085	0.5753	0.113	0.3514
Treatments	1	--	--	--	--	0.00002	0.9676	0.042	0.2079	0.363	0.0590
Error	5	--		--		0.067		0.101		0.306	
Specific Leaf Weight											
Blocks	5	0.000002	0.6686	0.000001	0.7444	0.00001	0.1579	0.000002	0.0924	0.0001	0.2684
Treatments	1	0.000002	0.1080	0.0000002	0.5093	0.00001	0.0085**	0.000003	0.0046**	0.0000004	0.4774
Error	5	0.000003		0.000002		0.000002		0.000001		0.000003	
Leaves per Crown											
Blocks	5	5.145	0.5790	3.483	0.5976	19.730	0.1773	4.683	0.9452	5.393	0.1586
Treatments	1	0.650	0.5017	0.758	0.3956	0.630	0.5617	1.050	0.6496	3.884	0.0281*
Error	5	6.207		4.395		8.158		22.534		2.072	

[z] Degrees of freedom are reduced by one for each missing observation. Significance at 0.05=*, 0.01=** and 0.001=***.

Table 75. Analyses of varience[z] for percent total nonstructural carbohydrates(%TNCS) for roots, crowns, canopy, leaves, petioles, stolons, plant; and percent nitrogen(%N) for roots, crowns, canopy and leaves on 'Earliglow' strawberry, autumn 1986.

Source	df	First Sampling SS	First Sampling Probability of F	Second Sampling SS	Second Sampling Probability of F	Third Sampling SS	Third Sampling Probability of F	Fourth Sampling SS	Fourth Sampling Probability of F	Fifth Sampling SS	Fifth Sampling Probability of F
<u>Percent Total Nonstructural Carbohydrates Roots</u>											
Blocks	5	14.889	0.2901	39.608	0.1483	8.352	0.9667	17.966	0.1968	13.714	0.3333
Treatments	1	7.696	0.0912	4.083	0.2898	19.279	0.2309	188.417	0.0001***	0.040	0.9486
Error	5	8.828		14.576		51.835		7.947		43.218	
<u>Percent Total Nonstructural Carbohydrates Crowns</u>											
Blocks	5	26.001	0.0904	13.522	0.1147	15.948	0.1716	10.284	0.9715	7.271	0.7753
Treatments	1	2.698	0.2267	0.476	0.4877	5.468	0.0946	23.241	0.2510	0.385	0.7339
Error	5	7.104		4.245		6.451		68.984		14.903	
<u>Percent Total Nonstructural Carbohydrates Canopy</u>											
Blocks	5	9.932	0.1817	7.177	0.2906	6.792	0.4276	7.675	0.6933	17.441	0.4369
Treatments	1	7.049	0.0336*	18.028	0.0061**	7.111	0.0550	7.346	0.1454	7.731	0.1696
Error	5	4.174		4.336		5.721		12.365		15.020	
<u>Percent Total Nonstructural Carbohydrates Leaves</u>											
Blocks	5	17.027	0.2906	12.519	0.0544	17.493	0.4118	7.402	0.8391	31.019	0.2329
Treatments	1	17.304	0.0328	21.547	0.0013**	16.709	0.0596	17.232	0.0870	4.783	0.2695
Error	5	10.109		2.591		14.183		19.086		15.530	
<u>Percent Total Nonstructural Carbohydrates Petioles</u>											
Blocks	5	7.739	0.6464	9.672	0.7173	9.764	0.0434*	16.347	0.5896	10.201	0.6873
Treatments	1	1.261	0.4836	11.078	0.1278	0.368	0.3584	3.630	0.3870	20.883	0.0518
Error	5	11.026		16.654		1.798		20.230		16.173	
<u>Percent Total Nonstructural Carbohydrates Stolons</u>											
Blocks	5	--	--	--	--	68.954	0.0712	54.034	0.6219	15.206	0.9523
Treatments	1	--	--	--	--	54.188	0.0098**	61.201	0.0949	35.323	0.1955
Error	5	--		--		16.488		72.374		79.181	
<u>Percent Total Nonstructural Carbohydrates Plant</u>											
Blocks	5	5.782	0.1661	7.044	0.1380	3.133	0.5173	2.695	0.6461	6.097	0.6542
Treatments	1	3.746	0.0354*	12.837	0.0038**	3.337	0.0733	16.901	0.0054*	2.391	0.3071
Error	5	2.290		2.477		3.264		3.836		9.093	
<u>Percent Nitrogen Roots</u>											
Blocks	5	0.228	0.0312	0.606	0.2087	0.353	0.7056	0.170	0.4377	0.462	0.2160
Treatments	1	0.001	0.6996	0.060	0.3474	0.198	0.2515	0.001	0.8980	0.034	0.4175
Error	5	0.013		0.280		0.588		0.147		0.219	
<u>Percent Nitrogen Crowns</u>											
Blocks	5	0.048	0.0925	0.057	0.5203	0.005	0.8616	0.030	0.4638	0.094	0.4085
Treatments	1	0.022	0.0413*	0.0001	0.9400	0.047	0.0087**	0.0001	0.9119	0.035	0.2295
Error	5	0.002		0.060		0.013		0.028		0.094	
<u>Percent Nitrogen Canopy</u>											
Blocks	5	0.011	0.7059	0.021	0.0895	0.024	0.2723	0.040	0.1149	0.016	0.1489
Treatments	1	0.005	0.3061	0.0002	0.6715	0.001	0.5355	0.015	0.0573	0.013	0.0116*
Error	5	0.018		0.006		0.013		0.012		0.005	
<u>Percent Nitrogen Leaves</u>											
Blocks	5	0.011	0.6494	0.020	0.4609	0.031	0.3302	0.038	0.4813	0.03[illegible]	0.4464
Treatments	1	0.014	0.0910	0.00001	0.9641	0.0001	0.8984	0.023	0.1313	0.06[illegible]	0.0225*
Error	5	0.016		0.019		0.021		0.036		0.03[illegible]	

[z] Degrees of freedom are reduced by one for each missing observation. Significance at 0.05=*, 0.01=** and 0.001=***.

Table 76. Analyses of varience[z] for percent nitrogen(%N) for petioles, stolons and plant; carbon/nitrogen ratios(C/N) for roots, crowns, canopy, leaves, petioles, stolons and plant; and percent fructose in leaves on 'Earliglow' strawberry, autumn 1986.

Source	df	First Sampling SS	First Sampling Probability of F	Second Sampling SS	Second Sampling Probability of F	Third Sampling SS	Third Sampling Probability of F	Fourth Sampling SS	Fourth Sampling Probability of F	Fifth Sampling SS	Fifth Sampling Probability of F
<u>Percent Nitrogen Petioles</u>											
Blocks	5	0.014	0.5350	0.010	0.0541	0.025	0.2211	0.012	0.2797	0.013	[illegible]
Treatments	1	0.00001	0.9602	0.013	0.0024**	0.0001	0.8665	0.006	0.1006	0.003	[illegible]
Error	5	0.015		0.002		0.012		0.007		0.009	
<u>Percent Nitrogen Stolons</u>											
Blocks	5	--	--	--	--	0.046	0.0304*	0.045	--	0.044	[illegible]
Treatments	1	--	--	--	--	0.0004	0.5254	0.000	--	0.055	0.3519
Error	5	--		--		0.001		0.000		0.021	
<u>Percent Nitrogen Plant</u>											
Blocks	5	0.036	0.7221	0.046	0.0827	0.032	0.7063	0.040	0.0454*	0.063	[illegible]
Treatments	1	0.010	0.4172	0.002	0.3676	0.021	0.2178	0.021	0.0138*	0.080	0.0452*
Error	5	0.063		0.012		0.053		0.007		0.057	
<u>Carbon/Nitrogen Ratios Roots</u>											
Blocks	5	3.979	0.3000	13.021	0.3382	4.381	0.9100	3.533	0.6372	2.697	0.9133
Treatments	1	0.587	0.3584	5.631	0.1334	0.749	0.6497	49.292	0.0009***	0.529	0.6357
Error	5	1.504		8.784		16.077		4.918		10.488	
<u>Carbon/Nitrogen Ratios Crowns</u>											
Blocks	5	13.289	0.1328	4.543	0.4363	4.616	0.1925	3.510	0.9557	3.262	0.4175
Treatments	1	0.240	0.5144	0.324	0.5481	3.247	0.0364*	5.525	0.2804	0.005	0.9233
Error	5	0.779		3.907		2.018		18.875		2.695	
<u>Carbon/Nitrogen Ratios Canopy</u>											
Blocks	5	2.372	0.2433	2.662	0.1265	2.200	0.5930	6.725	0.5015	7.149	0.4153
Treatments	1	2.212	0.0300*	5.453	0.0026*	1.766	0.1328	5.424	0.1013	3.829	0.1307
Error	5	1.227		0.887		2.745		6.748		5.867	
<u>Carbon/Nitrogen Ratios Leaves</u>											
Blocks	5	3.106	0.3182	127.633	0.3524	209.315	0.5131	38.455	0.9206	70.379	0.1171
Treatments	1	3.775	0.0274*	264.877	0.0120*	0.463	0.9216	156.151	0.0724	45.097	0.0242*
Error	5	1.988		89.313		215.859		151.402		22.149	
<u>Carbon/Nitrogen Ratios Petioles</u>											
Blocks	5	0.156	0.8834	0.323	0.5062	0.481	0.0905	2.579	0.0546	0.318	0.7399
Treatments	1	0.030	0.6034	0.224	0.1241	0.129	0.0780	0.168	0.2652	0.496	0.0947
Error	5	0.491		0.328		0.131		0.535		0.585	
<u>Carbon/Nitrogen Ratios Stolons</u>											
Blocks	5	--	--	--	--	3.658	0.3406	16.098	--	11.959	0.9631
Treatments	1	--	--	--	--	8.505	0.0954	0.000	--	1.371	0.7930
Error	5	--		--		1.890		0.000		12.947	
<u>Carbon/Nitrogen Ratios Plant</u>											
Blocks	5	0.994	0.4820	2.714	0.0813	1.969	0.6289	3.189	0.3355	3.307	[illegible]
Treatments	1	1.114	0.0603	4.531	0.0023**	0.181	0.5870	10.002	0.0047**	3.410	[illegible]
Error	5	0.953		0.701		2.683		2.136		4.562	
<u>Percent Fructose</u>											
Blocks	5	0.887	0.2688	0.052	0.7832	0.646	0.1372	0.237	0.7523	1.657	[illegible]
Treatments	1	0.004	0.5425	0.097	0.0888	0.033	0.4315	0.075	0.4054	1.108	[illegible]
Error	5	0.049		0.109		0.265		0.452		0.375	

[z] Degrees of freedom are reduced by one for each missing observation. Significance at 0.05=*, 0.01=** and 0.001=***.

Table 77. Analyses of varience[z] for percent glucose, sucrose, maltose and starch in leaves; fructose, glucose, sucrose, maltose and starch present of total nonstructural carbohydrates(TNSC) in leaves; and crown and leaf numbers of 'Earliglow' strawberry, autumn 1986.

Source	df	First Sampling SS	First Sampling Probability of F	Second Sampling SS	Second Sampling Probability of F	Third Sampling SS	Third Sampling Probability of F	Fourth Sampling SS	Fourth Sampling Probability of F	Fifth Sampling SS	Fifth Sampling Probability of F
Percent Glucose											
Blocks	5	0.028	0.8313	0.075	0.6227	0.677	0.0899	0.220	0.8323	1.144	0.1649
Treatments	1	0.000	1.0000	0.132	0.0504	0.097	0.1653	0.082	0.4291	1.338	0.0120*
Error	5	0.071		0.101		0.184		0.553		0.451	
Percent Sucrose											
Blocks	5	0.159	0.4370	0.032	0.8594	0.538	0.6342	1.069	0.4730	1.235	0.4881
Treatments	1	0.156	0.0624	0.001	0.8618	0.176	0.3256	0.791	0.1039	1.780	0.0417*
Error	5	0.137		0.091		0.743		1.003		1.201	
Percent Maltose											
Blocks	5	0.000	0.0000	0.000	0.0000	0.014	0.8973	0.044	0.3127	0.011	0.7579
Treatments	1	0.000	0.0000	0.000	0.0000	0.068	0.0422*	0.033	0.0583	0.006	0.2956
Error	5	0.000		0.000		0.046		0.028		0.022	
Percent Starch											
Blocks	5	15.697	0.4069	16.527	0.0080**	17.162	0.4337	12.240	0.6379	21.446	0.3675
Treatments	1	14.665	0.0611	15.534	0.0006***	27.684	0.0277*	6.355	0.2306	2.055	0.4538
Error	5	12.661		1.366		14.670		17.066		15.590	
Fructose Percent of TNSC											
Blocks	5	167.339	0.2512	79.833	0.0427*	81.666	0.0843	19.478	0.5093	535.054	0.2997
Treatments	1	167.892	0.0276*	15.503	0.0692	42.307	0.0257*	5.248	0.3029	31.649	0.5169
Error	5	88.644		14.567		21.451		19.908		325.800	
Glucose Percent of TNSC											
Blocks	5	140.825	0.2873	88.829	0.0271*	83.438	0.0646	17.117	0.7164	345.150	0.4385
Treatments	1	125.119	0.0404*	11.440	0.0894	52.060	0.0139*	3.949	0.4497	60.347	0.3608
Error	5	82.839		12.935		18.930		29.398		298.423	
Sucrose Percent of TNSC											
Blocks	5	67.403	0.6244	19.277	0.2347	15.415	0.9135	98.190	0.4946	189.932	0.2218
Treatments	1	1.201	0.8074	14.168	0.0427*	44.639	0.1067	15.285	0.4153	176.520	0.0268*
Error	5	90.848		9.705		57.836		96.942		91.769	
Maltose Percent of TNSC											
Blocks	5	0.000	0.0000	0.000	0.0000	1.311	0.8272	3.049	0.3812	7.356	0.4777
Treatments	1	0.000	0.0000	0.000	0.0000	6.190	0.0269*	0.981	0.2035	0.297	0.6639
Error	5	0.000		0.000		3.225		2.293		6.980	
Starch Percent of TNSC											
Blocks	5	904.015	0.4007	494.088	0.0068**	255.342	0.4237	246.824	0.3609	2082.893	0.2075
Treatments	1	531.168	0.1116	122.847	0.0100**	523.905	0.0172*	0.387	0.9207	741.215	0.1066
Error	5	713.464		37.799		213.055		176.496		959.434	
Crown Number											
Blocks	5	1.185	0.7409	1.444	0.6495	1.861	0.2713	2.444	0.4381	1.667	0.0866
Treatments	1	0.037	0.7827	0.037	0.7771	0.454	0.2009	0.000	1.0000	0.000	1.0000
Error	5	2.185		2.074		1.046		2.111		0.444	
Leaf Number											
Blocks	5	39.046	0.7856	90.046	0.6511	92.491	0.2488	95.963	0.0303*	20.556	0.6436
Treatments	1	1.565	0.7710	12.676	0.5159	18.750	0.2237	1.815	0.4682	19.593	0.1259
Error	5	82.824		129.824		48.639		14.741		29.074	

[z] Degrees of freedom are reduced by one for each missing observation. Significance at 0.05=*, 0.01=** and 0.001=***.

Table 78. Analyses of varience[z] for stolon number, total leaf area per plant and mean leaf area of 'Earliglow' strawberry, autumn 1986.

Source	df	First Sampling SS	First Sampling Probability of F	Second Sampling SS	Second Sampling Probability of F	Third Sampling SS	Third Sampling Probability of F	Fourth Sampling SS	Fourth Sampling Probability of F	Fifth Sampling SS	Fifth Sampling Probability of F
Stolon Number											
Blocks	5	--	--	--	--	10.222	0.1288	7.444	0.1801	14.630	0.0979
Treatments	1	--	--	--	--	3.000	0.0913	0.333	0.4971	0.037	0.8417
Error	5	--		--		3.444		3.111		4.185	
Total Leaf Area per Plant											
Blocks	5	225226.474	0.9530	619206.744	0.8231	1699706.186	0.0927	1853358.039	0.0071**	304915.545	0.1183
Treatments	1	602745.574	0.1702	596620.904	0.2175	845279.631	0.0303*	12547.121	0.5402	212585.236	0.0215*
Error	5	1175014.935		1499789.921		471168.348		145312.971		97545.580	
Mean Leaf Area											
Blocks	5	2002.663	0.5823	777.967	0.2737	876.014	0.5296	541.495	0.2579	2026.722	0.3294
Treatments	1	1712.549	0.1196	251.652	0.1517	735.273	0.1048	13.520	0.6511	6.931	0.8784
Error	5	2435.136		440.289		939.337		292.654		1336.312	

[z] Degrees of freedom are reduced by one for each missing observation. Significance at 0.05=*, 0.01=** and 0.001=***.